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FLUORESCENCE OR PHOSPHORESCENCE,

AND PHOTOGRAPHIC ACTION AT LOW TEMPERATURES.

PROFESSOR DEWAR'S LATEST EXPERIMENTS.[1]

Fluorescence and phosphorescence are terms applied to similar phenomena which apparently differ in degree only, the first being practically an instantaneous effect, while the other lasts for a measurable time. Familiar examples of fluorescence are seen in solutions of quinine sulphate, acidulated with sulphuric acid, and some specimens of paraffin oil. It has been shown by Stokes that the curious surface appearances observed in these liquids are due to a change of refrangibility of the light absorbed and again given off by their upper layers. Tait, writing on "Light," remarks that, "In every case the fluorescent light appears to belong to a less refrangible part of the spectrum than does the incident light which gave rise to it, thus affording an instance of dissipation, or degradation, of energy." The duration of fluorescence is very brief, and in this respect only does it seem to differ from phosphorescence.

[1] Professor Dewar's impaired health, consequent on the fatigues of an unusually arduous session, unfortunately prevented him from completing the article which we had hoped to publish in this number of THE NEW SCIENCE REVIEW. In order, however, that the readers of the REVIEW may not be disappointed at the absence of any contribution from his pen, Professor Dewar has very kindly communicated the material for the subjoined account of his experiments in regard to phosphorescence and photographic action, recently described and illustrated by him at the Royal Institution, London, in the presence of the members of the Chemical Society.

We may, therefore, regard phosphorescence as being merely a species of fluorescence which lasts for a much longer time after the excitation has ceased. Briefly defined, it is the phenomenon observed when certain substances give out light (usually in an altered form) which has been previously absorbed. In this—the most correct—sense of the term, it must not be confused with the luminosity due to the slow oxidation of phosphorus, the acid vapors from which shine in the dark with a faint, bluish light; nor with the phosphorescent appearance accompanying the slow combustion of decaying animal and vegetable matter; nor with the more or less voluntary display of light by fire-flies, glow-worms, and small marine animals.

The substances in which true phosphorescence was first observed were barium sulphide (Bologna stone) and calcium chloride (Homberg's phosphorus) during the seventeenth century; calcium sulphide (Canton's phosphorus), in 1768; and, later, strontium sulphide. When carefully preserved from the air, in sealed glass tubes, these compounds appear brilliantly luminous in a dark room, after exposure to bright sunlight, and for a long time present the general aspect of cooling bodies.

SOME OF THE PROFESSOR'S EXPERIMENTS DESCRIBED BY MONS. E. HOSPITALIER.

The result of the professor's investigations in connection with his work on the Liquefaction of Gases and Observations of the Properties of Substances at Extremely Low Temperatures, is that the list of truly phosphorescent bodies has been greatly extended and a knowledge of their peculiarities in this direction increased, and he has now demonstrated that oxygen is itself fluorescent.

On passing a stream of this gas or air, after it has been electrically stimulated, through a very large vacuum tube, highly exhausted, a comet-like globe of phosphorescent light was visible, and ozone was formed in the tube, apparently indicating that some kind of molecular change had occurred. It is essential that the air employed should be filtered, as any

considerable proportion of organic matter destroys the fluorescence, and the length of the luminous brush formed is inversely proportional to the amount of such impurity present. Even the dispersion of a little ether or perfume in the room may render this experiment impossible for several hours. Hydrogen also destroys the fluorescence. The phenomenon is produced only by gases containing oxygen, being shown to a slight extent by carbon dioxide. In the case of calcium sulphide, which after exposure to electric or magnesium light is highly luminous, cooling by contact with solid carbon dioxide diminishes the phosphorescence, and it is entirely suspended at —80° C., though subsequent warming restores the light.

ELASTICITY AS MODIFIED AT LOW TEMPERATURES.

The nature of the professor's work, which had led up to the results obtained in regard to phosphorescence, was illustrated by several experiments. The highly selective character of the oxygen spectrum was shown when a tube containing liquid oxygen was placed in the spectroscope, the dark bands being very distinctly visible in the spectrum thrown upon a screen. Further experiments illustrated the modification in elastic properties in bodies cooled to low temperature, the breaking strain of metals, for example, being increased. This modification of elasticity—both longitudinal and torsional—was clearly shown by cooling spirals of very soft metal in liquid oxygen to —180° C., when they became perfectly rigid and sonorous, like iron. The influence of similar cooling upon hard steel was demonstrated by comparing the notes from two tuning-forks in perfect unison. On cooling one to —180° C. its elastic constants were modified, thus causing it to vibrate more quickly than the other, while the number of beats showed the increased elasticity.

PHOTOGRAPHIC ACTION AT LOW TEMPERATURES.

No direct chemical action can be brought about by the contact of bodies like liquid oxygen and phosphorus or potassium. Nor can any form of voltaic cell continue to produce

electricity when cooled to —180° C. Photographic action can, however, be carried on at the lowest temperature yet reached, though reduced to the extent of more than eighty per cent. at —200° C. Thus, chloride of silver paper, when partly sponged with liquid oxygen and exposed to bright light, quickly turns brown, except where cooled; little or no action taking place at that spot. In the case of two very sensitive photographic films, in which chemical action had taken place at similarly low temperatures, magnesium wire had been burnt in the dark room as a means of stimulation, and phosphorescence had resulted.

It was also shown that the colors of bodies and their specific absorption are materially affected at low temperatures. Thus, liquid oxygen turns red; iodide of mercury, yellow.

CONCERNING OTHER PHOSPHORESCENT BODIES.

The professor's next experiments were devoted to showing that gelatin, celluloid, paraffin, ivory, horn, and India-rubber become distinctly luminous, with a bluish or greenish phosphorescence, after cooling to —180° C., and upon being stimulated by the electric light. Hydrokinone is more luminous than the isomeric resorcin or pyrocatechin; in the same way pyrogallic acid was shown to be faint as compared with phloroglucin. All alkaloids forming fluorescent solutions become phosphorescent at low temperatures. The hydrocarbons, alcohols, acids, and ethers, of the fatty series, are all more or less active, and glycerin, sulphuric and nitric acids are all very bright, whilst concentrated hydrochloric acid and strong ammonia are also very bright. Colored salts generally show very little activity. Water, when pure, is only feebly phosphorescent, but remarkably so when impure. Acetic acid and acetanide appeared fairly equal in luminosity; hippuric acid was very fine, and so were most substances containing a ketone group. Lithium platino-cyanide changed from white to red on cooling, and was excelled in phosphorescing power by yellow ammonium platino-cyanide, which was exceedingly bright.

Definite organic substances possessing exceptional powers of phosphorescence when stimulated at —180° C. are acetophenone, benzophenone, asparagin, hippuric acid, phthalic anhydride, urea, creatin, urethane, succinimide, triphenyl methane, diphenyl, salicylic acid, glycogen, aldehyde, ammonia, etc.

SOME REMARKABLE RESULTS.

Very remarkable were some results obtained by the professor with an egg and a feather. The egg shone brilliantly as a globe of blue light, and the feather was equally brilliant, its outline in the darkened theatre being clearly seen.

Other organic substances giving excellent results were cotton, wool, paper, leather, linen, tortoise shell, and sponge, all of which phosphoresced brightly, as did also a white flower, a cultivated species of dianthus. Colored glasses and papers do not, as a rule, exhibit any phosphorescence, and when the alcohols are colored by the addition of a trace of iodide, the luminous effect is destroyed. Milk was shown to be highly phosphorescent and much brighter than water.

Metals also phosphoresce, but in this case the action is due to some organic film deposited from the air, because it disappears on ignition. If the metal is subsequently touched, the phosphorescence reappears.

Ordinary albumen is one of the most difficult bodies to cool properly, on account of its tendency to expand and break the tubes. It was shown, however, to possess greater phosphorescing power than the yolk of an egg, white bodies being generally inferior to colored ones in this result, and on cooling a layer on the outside of a test tube and exposing it to light passing through a quartz lens it exhibited a marvelous brilliancy.

The difference in luminosity when glass intervened was, of course, due to the fact that glass is somewhat opaque to the violet and ultra-violet rays, the latter of which are most necessary to stimulate bodies and so induce phosphorescence.

Caustic soda, and many salts not normally phosphorescent, are markedly so at low temperatures. As a rule, the chloro-, bromo-, sulpho-, and nitro-substituted bodies show nothing,

XUM

or are but faintly luminous. Among basic bodies, nicotine is more luminous than quinoline or pyridine.

[NOTE.—Possibly, as an outcome of these experiments, some connection may be shown to exist between phosphoresence and the structure of matter. Already Professor Dewar has reason to believe that bodies may be naturally classified, according to their luminous power, at low temperatures. As a provisional generalization, it may be considered that the greater the complexity of structure in a body, the more likely is it to phosphoresce; probably on account of the increased facility with which its structure enables it to take up the light vibrations. Again, the luminosity of some of the heavenly bodies may be due to phosphorescence at extremely low temperatures. However this may be, Professor Dewar's researches will probably throw fresh light on the constitution of matter; and further developments will be awaited with general interest.]

"WHAT ELECTRICITY IS."

(Scientific opinion is invited.)

"Do you suppose we will ever know what electricity is?" As I have been asked that question more frequently than any other since I became an electrician, I will try to clear the electrical atmosphere a little, and endeavor to bring this apparently mysterious agent down to the level of those forces with which we consider ourselves on more familiar terms, and in this attempt the reader is presumed to have only a common school knowledge of matters scientific.

Before considering, however, the immediate question what electricity is, it will be well to ascertain first what we really know about other natural forces, such as gravitation or heat, both of which we observe in daily operation with a sort of contempt that is born of familiarity.

What, then, is gravitation?

After a little reflection we are compelled to admit that it is quite beyond our powers to define clearly what gravitation is. We can only say at best that a terrestrial force affects all material bodies in accordance with certain fixed principles called the laws of gravitation, and on asking some professor of science the question, he replies: "Gravitation is a manifestation of energy, and its laws are so and so."

Let us try again. "What is heat?"

Heat, we say, is a mode of motion, but we at once concede that this definition is rather unsatisfactory, and does not give us a clear idea what heat is. We know, however, that heat affects different material substances differently. The same degree of heat, for instance, melts one substance and freezes another, and we make daily use of this knowledge.

Going again to the professor of science, he replies as before, that "Heat is a manifestation of energy, and the laws of its action are so and so." We note that his answer is the same to both questions, so he has made at least one significant idea plain, which is this: Both heat and gravitation are manifestations of energy, and so far at least are one and the same thing. The only important thing, after all, seems to be a knowledge of the laws that explain the action of these forces when at work, for this alone makes them subservient to our needs.

Every form of force, therefore, should be regarded as a different method or way in which the same thing, more properly spoken of as energy, makes itself known to the senses.

Of energy itself we can have no intrinsic knowledge, because it is intangible and invisible; and electricity is no more mysterious in this respect than heat or gravitation. It is fortunately placed within our power to learn by study and experiment the laws that control the action of any force, and it is, indeed, a great thing to say, even in this nineteenth century, that the laws defining the behavior of electricity, though of comparatively recent date, are as clearly formulated and as thoroughly understood as are those concerning heat or any known force.

The expression, "Energy in the form of heat, energy in the form of electricity," etc., is a trifle clumsy, but very conducive to clear reasoning, and leads us to the consideration of an important law of nature, which, thoroughly grasped, will bring the answer to our question, "What is electricity?" clearly into view.

This law is known as the principle of the conservation of energy, and teaches that energy or force, like matter, is indestructible. Thus, for illustration, a smith beats a nail with

a hammer—raising the hammer against the gravity force, he brings it down with considerable power. He is not only doing work, but he seems to be expending or actually destroying energy, for to the superficial observer a certain amount seems to disappear at every blow, but the principle we are now considering tells us this cannot be the case. It tells us that force cannot be got rid of, it only seems to disappear by changing form, always appearing somewhere else in a new guise or dress. Thus, as the nail is hammered, we soon become aware of a new form of energy that has appeared on the scene without any apparent reason or excuse for its presence. In fact, the nail has become hot, and the question arises, Where did this new energy in the form of heat come from?

We now know that the heat apparently born of the action of hammering is the mechanical energy expended by the smith appearing in a new form; it is the same identical energy that was delivered to the nail by the blows of the hammer, and precisely the same amount. That is the conservation of energy.

Having this law clearly in mind, we are prepared to attack the main question, "What is electricity?" for the law says that all force is one, though its guise or form of manifestation may be undergoing ceaseless change.

Take an illustration that comes a little nearer to our subject. Nothing at first appears so mysterious as the attraction a magnet exerts upon a piece of iron or steel, but this is only because we are not accustomed to deal with this form of attraction, and on reflection we are forced to the conclusion that magnetic attraction is no more to be wondered at than the attraction of gravitation; both are phenomena of nature, and both are equally calculated to excite surprise at first view.

Whenever a force of attraction holds two bodies together, or tends to do so, we use some other force, generally in the form of heat, to separate them. Thus a heavy body rests upon the earth, held there by gravity; to lift it we use mechanical energy. In some way, however, this mechanical

force always comes from heat, as when a steam engine is made to do the work; or if muscular power be used, as that of a man or a horse, the power is still traceable to the same source, for in this case also the force exerted originates in the heat energy of the food, made available for use by combustion in the body, which is furnace, boiler, and engine all in one machine, and which enables us to exert the muscular power derived from the heat energy of food in a useful way.

If, on the other hand, gravity attraction is free to work by causing a weight to fall from a height, then whenever the falling body is either arrested entirely in its course, or its motion is merely checked by a resistance, the gravity force at work passes to the heat form.

These transformations between mechanical energy and heat are quite generally understood. They are merely dwelt upon here because of the close parallel that follows when we apply the principle of the conservation of energy to cases less familiar.

Return now to the magnet which holds a piece of iron so firmly that it requires considerable force to tear it away, and suppose power be applied to remove it. What becomes of the mechanical energy thus exerted? It seems to have passed entirely out of existence, and it will require the closest scrutiny to follow the elusive changes of force that take place in this simple act of separating the iron from the magnet. We may be sure, however, that the force has been neither lost nor destroyed, and we must look for its appearance somewhere in the system in which the mechanical force was expended.

Continue for some time to rapidly apply the piece of iron to the magnet, and as quickly pull it away again. It will in time become warm, and eventually hot, as a result of this process, and so will the magnet also, though in a less degree.

Here then is force, that was originally exerted in the mechanical form, as push and pull to overcome the attraction of the magnet, appearing as heat in the piece of iron, and it looks very much as if we had simply converted mechanical energy into heat, as before explained. Energy,

XUM

however, is often very elusive in passing from one form to another, and closer investigation in this case will show that the change from the mechanical to the heat form involved another step which escaped our notice, simply because the intermediate form of force was not evident to the senses. Thus our senses, too completely relied upon, are apt to cheat us sometimes. The truth of the matter is that the mechanical action of pulling the piece of iron away from the magnet and putting it back, set up electric currents in the mass of the iron, which, though not apparent to the eye or the sense of touch, could be detected by a compass; and these currents flowing back and forth in the iron heated it, because every conducting substance, however good a conductor of electricity it may be, opposes some resistance to the flow of electricity through its mass, and if the electricity is forced through it against this resistance, the conductor will be heated as a consequence. We see, therefore, that two transformations took place in the iron instead of one.

Mechanical force applied to remove the iron from the magnet was first changed to the electric form of energy, existing as electric currents in the iron, but discoverable only with a compass or other suitable instrument, and not evident to the senses. The iron, however, opposing a resistance to the flow of the electric currents in its mass, altered the energy again to the heat form, when it became again evident to the senses, but in passing through these different stages it was always one and the same energy, different conditions and resistances having twice quickly altered its form or mode of manifestation.

It is important here to note how resistance of one kind or another is always the agent that acts to alter energy from one form to another. The attraction of the magnet (magnetism) opposed a resistance (mechanical) to the iron being pulled away, but this resistance was overcome, and the original forces were altered instantly by the resistance to the electric form, existing momentarily as electric currents in the iron. The iron opposed, however, an inherent resistance to the flow of electric currents through its mass, but they must

flow because the iron was forcibly pulled away in the first place—the fact which started all these changes going, and which must come to a logical end. The resistance the iron opposed to electric flow was therefore overcome, but as a direct result the force at work (electricity) has again changed form, and now appears as heat, in which form it is radiated and dissipated into surrounding space.

It would, therefore, appear that electricity, as we have here observed it, is simply a form or manifestation that the one force better spoken of as energy may assume under given conditions, and generally, as in the case cited, it is a mere transitory stage between the mechanical form and the heat form.

In most operations mechanical force passes to the heat form without passing through the electric form; but, whenever magnetism is brought into play as a resistance that must be overcome, then mechanical power applied to overcome this resistance always becomes electricity, if only momentarily in its passage from the mechanical to the heat form.

Can we not now answer in a fairly satisfactory way the question, "What is electricity?" by saying that it is simply a form that energy may assume while undergoing transformation from the mechanical, or the chemical, form to the heat form, or the reverse?

In this attempt at a definition I have purposely referred to energy in the chemical form, not heretofore referred to, as it is not apparent from the illustration given where the electric current of a battery comes from, and how, in this case, it is also traceable to a mere transformation of energy.

There are, fortunately, many ways of obtaining energy in the electric form; but in nearly every case, if not quite all, it will exist as a transitory state of energy in its passage from some other form to the heat form. Thus, in the case of a battery, we start with energy in the chemical form, by which we mean the affinity or strong tendency that an acid has to unite with a metal to form a new combination, this chemical energy or affinity being a potential force of nature, like gravitation or magnetism.

XUM

As long as the circuit of the battery is closed, or, in other words, as long as a path is afforded for the electric current to flow, the chemical change will go on. When the path is broken or interrupted in any way, the chemical change will practically cease, because no transformation to heat through the electric form can now take place. While, however, the path is closed, chemical change is going on, an electric current is flowing through the wire path, the wire becomes heated, and there is dissipation of heat by radiation from the wire, in direct proportion to the amount of chemical energy expanded; but the energy, before appearing as heat, has been momentarily in the electric form, and can be discovered by placing a compass under the wire path, which is made hot by the invisible and intangible electric current.

Thus, the definition derived from our simpler illustration, holds also true in this case, and the conservation of energy, rigidly applied, will thus make the existence of force in any form clear to the eye of the mind.

MENTAL TRAINING—A REMEDY FOR "EDUCATION."

WILLIAM GEORGE JORDAN.

There are two great things that education should do for the individual—it should train his senses, and teach him to think. Education, as we know it to-day, does not truly do either; it gives the individual only a vast accumulation of facts, unclassified, undigested, and seen in no true relations. Like seeds kept in a box, they may be retained, but they do not grow. For years the mind is filled with facts that the mind is not trained to digest. To the physical body food is of value only when it is digested, so it is in the mind, with mental food; but if digestion were made continuous, perfect, and ever equal to the supply of food, overfeeding either in mind or body would be impossible. But in the education of to-day the digestion is not equal to the feeding.

The greatest educational need of the individual is a trained mind—a mind that is ready on the instant—not the next day. With most persons the intellectual brilliancy, the proper thing to say, comes as an after-thought. An after-thought is but a beautiful possibility designed to fit a lost opportunity. It is no more helpful to a man than a flattering epitaph on his tombstone. With most persons this wit is like a night telegram,—it is not delivered until the next morning. Man expects his hand to be instantly ready to perform any motion of which it is capable; but he is resigned if his mind does not act quickly. He says that readiness is born with people; it cannot be acquired. If man's heart, lungs, or stomach are weak, he consults specialists, and never gives up until he obtains relief. But if he cannot remember names or faces; if he is subject to that intellectual remorse known as after-thought; if he has no eye for color, or taste for music; if he has no command of language; if there is lack of power in any respect in his mind, he is perfectly resigned, and says, "I am as God made me, and so I must remain." When man fails he always does this. He says, "I am as God made me;" but when he succeeds, he proudly proclaims himself a "self-made man." It is not necessary to submit to any mental weakness. Training will do even more for the mind than for the body.

The system of mental training by analysis, law, and analogy briefly outlined in this paper, seeks to educate the mind, to quicken, intensify, and develop its working, as a physician does with the body, toning, and exercising all weak parts. By a system of exercises it would train every sense, every faculty, every memory, every power, part, and phase of mind, every mental muscle, making it supple and instantly responsive,—as a massage stimulates the body. It would reveal to man his power and his weakness, teach him to know himself. Man, whatever be his line in life, needs a trained mind—one quickened, and in best health and condition, to be used in whatever be his activity. Education should give all men this general ground-work of power, even if it give nothing more. An untrained mind is like a torch,—flickering,

XUM

uncertain, scattering, wasting, and losing its light. The trained mind is like a search-light, that instantly can turn every ray of its energy in perfect concentration upon any one point. It is not the energy it takes to do a thing that tires men, it is the energy they waste. Most men every day waste enough energy to run a genius. The fault with persons is, not that they have not good minds, that they are not naturally bright, but merely that their minds are not trained, not systematized, not reduced to order. This power "education" does not give; but it should give it as the fulfillment of its first duty. In aught that may seem sweeping in this article, I wish it understood as relating to the "system," and in no wise a criticism of the splendid work of individual teachers, professors, and other educators who have been successful. Whatever success they may have had has been in revolt against conventional machine-methods.

Medical science to-day tells us that a single fundamental weakness in one organ in the physical body may assert itself successively in the course of years under perhaps a dozen distinct phases in as many parts of the body. All may be traceable, if our diagnosis be sufficiently analytic to discover the unity masquerading beneath these disguises, to one disorder. To this "root" we must direct all our energies. So it is with the many weaknesses and failures in the education of to-day. The root-weakness is *constant impression without a corresponding expression.* Under a hundred phases is this constant basic failure shown. Before pressing this point further, let us seek for a moment to simplify the workings of the mind.

The mind may be divided roughly into three parts, or faculties—Impression, Repression, and Expression. The first, Impression, receives all raw material through the senses—seeing, hearing, touching, smelling, tasting, and the muscular sense. The second is Repression, or memory, which by cerebration analyzes all this raw material, combines, recombines, deepens, and classifies it ready for expression. The third, or Expression, uses the material the senses have received and memory has classified,—in writing, speaking,

clear formulation in words, drawing, or some other form of outward activity. Any thought expressed becomes modified by meeting new thought, re-enters the mind, is again retained in memory, again expressed; and this trifold process is endlessly repeated. In the perfect mind this process is constant and continuous; in all minds the *tendency* to this is as natural as the circulation of the blood. Our modern education forces material into the mind (and even this through untrained senses) and, without a corresponding expression, the mental food becomes congested, clogged, and unavailable. Impressions, instead of being classified for instant readiness, are buried under succeeding layers of impressions, as geologic strata overlie and conceal each other.

Does not all the inability of an ordinary college graduate lie in this matter of *expression?* Is his mind quick to analyze a new subject and to see it in its relations? To ask a good question? To give a quick illustration? To make a fair description? To be ready in conversation? To sum up, to epitomize, to formulate his own views? To make a generalization? He has information, but so has a library; he has a vocabulary, but so has a dictionary. To be of service to him in the battle of life his information and his vocabulary must be held in immediate readiness. Mental training recognizes these three divisions; gives each careful exercises to keep each in its best condition as a part of the instrument, and then trains the mind to pass every impression through the trifold process—a training that soon results in automatic action. Perfect education in any line is but conscious training of mind or body to act unconsciously.

This system of training by analysis, law, and analogy is seen in perfect working in the mind of a child before it has been perverted by false education. The mind of the child is constantly analyzing. It is constantly seeking to trace effects back to causes; to predict effects from causes: it then seeks constantly to know the how, the why, the reason, the law governing what it sees. Then the child, wiser than it knows, grasps the great truth that all law is universal, and seeks to project the law discovered in the single instance into

other fields by analogy, saying, "Well, if that's so, then this must be so." A short time in public school tends to weaken and almost stifle this process forever. The mind of the greatest philosopher cannot rise above this trifold process of analysis, law, and analogy; his discoveries become great only as he dares to use this process to its perfection; dares to project it far into the hidden mysteries, reach the revelation, and then verify the revelation by slow, careful presentation of attesting facts. Newton's discovery of the law of gravitation and Darwin's law of the survival of the fittest were but supreme manifestations of this process. And a process, too, so wonderful as to be seen on close, careful study, in a minified form, in every instance wherein the mind has done its duty. This bird's-eye view of the subject forbids fuller amplification of the possibilities of these three words, analysis, law, and analogy. But when taught in this spirit, with growing reverence for law, from its most simple phase of mere "why" in a trivial instance, to the grandeur of some majestic law that binds a million of these "whys" into a simple formula,—like a great cable of countless strands,—mental training becomes more than mere mental education. The recognition of the inevitability of consequent that comes from the growing belief in law—law, natural, mental, physical, moral, spiritual—soon enters into the very fibers of man's character, and becomes an ethical training that puts him into harmony with all that is best, all that is highest, noblest, and exalted. It shows him that his true mental training must be based on the harmonious quickening, perfecting, and unifying of his mental, his physical, and his moral nature.

Returning to the training of impression, the beginning of all true education should be the direct training of the senses of the individual. It is of vital importance that they, the instruments that bring to him all the raw material of thought, should be trained to bring clear, vivid impressions to the mind. Man may need his Latin, his Greek, or his calculus occasionally in daily life, but his trained senses he needs every moment. He needs to remember a face; to recall a

date; to have some one's name ready on the tongue in an instant. Hundreds of instances might be cited to show the constant call upon the senses, and man may blame his mind as weak and unreliable when it is merely his senses that have been shamefully slighted and perverted. A piece of wood that a man with a dull knife spends an hour in shaping into a rude, clumsy boat, represents but the easy pleasure of a few moments if that knife were sharp, sure, and quickly responsive to his directing. "Education" is long, hard, tedious, and a comparative failure in the end, even from the standpoint of mere memorizing, partly because of this fundamental neglect of the senses. The child at its geography lesson, in so simple a thing as bounding the States, wastes a terrific amount of energy with but little real permanent gain. With hard study he goes over the boundary by rote, rehearsing the combination of descriptive words until he has them "fixed in mind," so that they may be glibly presented to the teacher on demand. This gives the child but the sequence of words, not a distinct idea of the situation of the State that is desired. This is the hard, tiresome method of most children. Were the child trained by exercises in the sense of sight, he would take a clear, vivid, and permanent mental picture of the map of the United States which he would never forget, and which he could revive at will.

Many men fail in spelling, hopelessly surrendering to the belief that they "never can learn to spell," because the power of visualizing words has never been developed. The study of language, and the power of the sounds of words and of their correct pronunciation, must come through an appeal to the ear. There are few, relatively speaking, even among our best educated men and women, who give the true, pure pronunciation of words in our own tongue. Often they cannot detect any difference between two distinctly different sounds of a vowel, showing that the ear has not been trained to delicate discrimination. This training is too vital, too far-reaching in its possibilities, to be passed by with incidental, occasional exercises in color, form, and size. It should be the slow, careful, systematic training of all the senses—sight,

hearing, touch, taste, smell, and the muscular sense. Beginning in the very lowest classes with simple, easy, and interesting exercises and environment, this training should never be lost sight of during the whole school and college course of the individual. If modern education does nothing more than this, if it would do nothing more than give the individual command of his senses, and teach him to *think*—this alone would be great, infinitely better than making him a mere weak solution of a hundred text-books.

The kindergarten does excellent work in the earlier training of children; but even here is grave danger of merely exercising impressions, and of falling in with the one-sided development of the age, in making the exercises almost exclusively an appeal to the eye, with but little definite and specific call upon the other senses. But each of the senses is of vital importance. Each has its limited range of impression, and no one can perceive what any other perceives. The eye sees color; but we cannot smell, hear, taste, or touch color. To perceive any phenomenon perfectly, we must test it by all the senses, and no development of any one can compensate for the lack of training of another. Our concept of anything is formed from the union of impressions received through all the senses. With any one sense weak, our impression of the whole is weakened in proportion. An illusion is something that deceives one or two of the senses; but this is usually corrected through one of the others. No illusion is clever enough to deceive all the senses. The six senses are placed as six separate sentries to the mind; they separately challenge every phenomenon, making it name not one pass-word, but six, before admitting it to the mind. Therefore, each of the senses should be trained. But in our lack of training we have permitted this beautiful coöperation, this exquisitely perfect system of nature for the testing, classification, and mastery of each fact, to fall into disuse.

Training the senses should exercise them constantly and progressively (1) in taking clear, distinct images; (2) in vivid reproductions; (3) in increasing the grasp of each sense, and (4) in widening its range. These four phases are vital parts

of all training. The importance of clear, mental images in the mind cannot be overestimated, and as this imaging is developed more and more, the mind grows from vividness in appreciation of concrete images to strong power in imaging the abstract; of thinking in phenomena. By constant exercise in taking clear mental images, the mind is soon able, with a single glance of the eye at a statuette, a print, a face, a name, a date, a scene, to retain it in all its completeness in the mind. Then the process of analysis, a constant accompaniment of every observation, a vital part of mental training, classifies it in the mind in a certain relation, illustrative of a certain thing, or connected with something else. This analysis fixes the impression as an acid makes permanent the tracings of an etching on a sheet of copper. The methods and exercises by which these senses should all be trained for long years, cannot here be even suggested, nor can the plea for proper consideration of the so-called "lower senses" be more than noted in passing. Memory in all its completeness is but the memories of the separate senses. Whenever, then, we train a sense to perfect working, with analysis, we train the memory of that one sense. No complicated system of mnemonics or chain-words is necessary. Many of the memory-systems now in vogue, those based on artificial associations, are clumsy expedients, like taking a steam-engine to run a watch.

Constant training in *words* is a vital part of mental training. Words are but symbols for mental images. As we quicken the mind to analyze and to note delicate differences and shades of meaning, we are intensifying its powers of expression to greater care and accuracy. This at once reacts upon the impression, making the mind keener and clearer in its classification, and more quickly responsive in action. This is but one phase in which this constant analysis in the mind is trained to higher and more accurate thinking. This one great need in education to-day is passed by with a trivial recognition that is a disgrace to education. There can be no clear expression if there is not clear thinking. One great failure in our education is that there is too much memorizing of mere words, instead of memorizing of mental images or

pictures that these words call forth. Words should be looked upon as living things; to be studied in themselves, in all their forms and phases, rather than merely studied about. We should have laboratory work in words. Mere study of synonyms from books will do but little real good; the words must be studied in life. I have found classes intensely interested and quickened for an hour or more in the study of a few lines of newspaper writing; perhaps but a criticism of some famous man of the day. It was studied word for word. If any word was adjudged strong or fitting, the reason why it was fitting in that situation was discovered; if it was weak, in what respect it was weak. If it meant more or less than the thought required; if it suggested an association or an element not in harmony, another word was substituted. In this was something higher than mere dogmatic individual criticism; for be the word good or bad the choice must be justified. The critical and the imaginative faculties of mind were here trained together; for every substitution of a new word was an appeal to the imagination sustained by the judgment. Thus, the ear became wondrously quick to perceive the force of a word, its music, its fitness. Words of color were studied; words of size, and number, and form; words expressing the extremes of ideas; words expressing differing degrees of intensity of the same quality; the power of short words; onomatopes; words of every class, looked at from every point of view.

In the beginning of these exercises in words there were many students who "felt a difference between the words, but could not express it." A few questions, however; a few tests; or the stimulation from the general discussion, soon showed that the power of expression needed only to be developed. We have many teachers in our schools, and professors in our colleges, who value words, and seek to teach in this spirit, so far as the rigidity of the system will permit; but this is not enough. This study of words is so vital an element in the training of the mind, that it should be begun in the very earliest classes, and never be lost sight of in the whole school and college training of the individual.

Compositions are written by the pupils, and returned to them with a few red ink interlineations and corrections of misspelled words, mispunctuation, wrong capitalization, or errors in syntax, and but the occasional substitution of a better word. One hour's study of words before a class, from any one of these compositions, would be worth more than a whole term of the usual work.

Questioning is a vital element in this training. Few men can ask a good, direct question, that pierces the very heart of an issue. This ability to question must be ready on the instant; the next morning the man and the golden opportunity have gone. When a man's mind is trained, he not only has his knowledge classified, but his ignorance formulated as well. He knows what are the points of which he is in doubt. On the subject of faith-cure, for instance, a trained mind would have perhaps a few clearly-defined questions, doubts, possible misconceptions, as they have been accumulating for years, all ready to be delivered in systematic sequence at the opportunity. These represent what the mind has left over on the subject after it has classified his knowledge of it. These remnants, shreds, and rough edges of ignorance the mind carefully assorts and piles neatly by the side of knowledge. The ignorance is ever ready to move into knowledge. The goats may become lambs, in the miraculous mystery of mental processes, at any moment.

Conversation—one of the great educational needs in the life of an individual—is passed by without notice, yet few powers are of greater value to man's success and pleasure in life, than quickness and readiness in conversation. The ability to give an apt illustration, exactly paralleling a thought in more familiar lines, is a rare power, but there is no reason why it should be so if men were trained instead of being merely "educated." The ability to define, to describe, to formulate, to systematically approach and study a new subject or idea, to make individual deductions, should be the subject of daily exercise. Reading, in all its phases; the power to absorb, to select, to condense, to epitomize; the ability to know how to study reference books; to use what one has read, not

as he has read it, but as that reading has become absorbed and permeated by his individuality, should mean daily exercise for years. This mental training seeks to give man a full, rounded development; building up his mind and strengthening it wherever it is weak. It must not be thought that mental training would be a great cost to the State, for with a decreased list of studies, and a diminution in the years of service required for the course, it would really cost much less than the elaborate menu now provided.

A single illustrative case from memories of mental clinics will make my meaning clearer as to the practical use of analysis, law, and analogy in observation. To a gentleman taking a course in mental training, I was speaking of the importance, in observation, of constant preparation for instant use, and of the value of passing every impression through this trifold process. We were just leaving the Museum of Art, when I asked him what he had observed, what he had classified and stored in his mind from what we had seen; for we had gone to the gallery with the idea of training rather than for the mere æsthetic pleasure of the pictures. He said he could not recall anything special, but he gave a good list of statues and pictures as we had seen them, showing that his eye-memory was well developed. "This," I said, "is good so far as it goes. But in itself it is not observation. The mere use of the senses is not observation. They are but the instruments of observation, as the telescope is the instrument of the astronomer. Observation is impression *plus* deduction; impression *plus* individual interpretation; it is what we see, *plus* what we think of it. A photographic camera can retain what passes before it, but it cannot *observe;* the phonograph, that marvelous new ear of science, can hear and repeat what it has heard, but it cannot *observe.* In every observation there should be a deduction, a judgment, a classification, the beginning of an attempt at generalization.

"Let us now test the gallery by our trifold process of analysis, law, and analogy. First, what picture in the whole gallery did you like best?" This forced him to pass every

picture that he remembered in the gallery through a process of analysis, more or less perfect, qualitative and quantitative. After a few moments he decided on "Thesnulda before the German Court." You remember the painting, a tall, regal woman leading a child by the hand. She stands a captive in queenly contempt before a barbaric Teuton court, lying at ease on skins of animals. "What is the focus of the picture?" was the first question. "Thesnulda." "Wherein is the great power of Thesnulda?" "Her face." "Now we have roughly analyzed it, let us seek the secret of the face, its force, its law. What does the face mean, what does it show?" In a few moments we decided that "it was the noble superiority of a great nature that, in the moment of its abasement, rises above its persecutors." "And now for the analogy. Where in all your reading, conversation, or observation can you recall a situation wherein such an expression would have risen on the face of any individual?" "Galileo, when he said, 'but the earth does move.'" "Another?" After a little hesitation he said, "John Huss at the stake, when they lighted the fagots." "Another?" "Regulus before the Carthaginians." "Another?" "The same expression, softened, purified, and sanctified, would appear on the face of Christ on Calvary." "That is enough. You have passed this picture through the process of analysis, law, and analogy, and have formulated a clear expression for your impression. It may be that years from now you will again see such a face, or hear of it, or read of it. Your prepared formulation will spring forth of itself; you will not have to halt and stammer, and then build up a weak, tentative expression of it. At the same time, the instances of Thesnulda before the German Court, Galileo before his persecutors, John Huss at the stake, Regulus before the Carthaginians, and Christ on Calvary, will be revived together. You have trained them to answer to a given call. You have made an appointment with them. You have started a new centre of localization in the brain, at which all similar instances later will be automatically classified. They are grouped, not by any accidental resemblance, but by the highest psychological basis of classi-

fication—law, the oneness of relation between cause and effect shown in all."

A few other pictures were then studied, with a remarkable increase noted in quickness and grasp. In these exercises it was all individual work; he was not repeating what he had heard, he was thinking for himself. Some one else might have given only one, weak analogy, but the process would have been the same. It may be said that this would be an exceedingly tiresome process if one had to go through it every moment, with each new impression. It *would* be tedious were it always conscious; but it is only a matter of effort for a few times, then, at the mere glance of the eye, the mind carries out the process. It would be hard if we always had the same difficulty in writing our names as we did at our first trial; if bicycle riding were always accompanied by the early "headers" and the delicate studies in equilibrium; but these efforts soon sink as processes below the horizon of consciousness, and become almost automatic. We are in this exercise, and in all others, only intensifying and quickening a process all go through. It may be in a very vague way, so misty as to seem only an emotion of pleasure, or a feeling of interest without thought of process, or so almost simultaneous with the impression as to seem instant and indescribable. This process would not blunt the æsthetic pleasure in the pictures, any more than a man's enjoyment of a banquet would be lessened because the food were being perfectly digested.

One of the new type-setting machines has an ingenious mechanism for distributing the type after it is used. The ninety different pieces of type used have as many different kinds of nicking, all types of the same letter being nicked identically. A large cylinder, with longitudinal ribs extending from top to bottom, holds the type. These ninety ribs are bent to correspond to the nickings of the type, and these pieces of type fall in a continuous string as the key-board is manipulated. In distributing the type after using, the "matter" is placed, just as it is taken from the press, on a revolving drum over the stationary cylinder, of the same diameter.

As the upper drum revolves, each piece of type falls when it reaches the ridge to which it corresponds. In the same way with a trained mind, the illustration, thought, word, or comment, drops down automatically at the pressure of need. This is not an artificial system of mental training to "teach one never to forget." It is not *memory* training, but *mental* training. It is training the mind so that each new impression calls out the classified activities of the mind on the instant. If you put a package on the pan of a grocer's scale, the index figure moves round on the dial and stops at the number indicating the weight. If you press in succession a number of buttons in an adding machine, instantly the sum of those numbers is flashed before you. So it should be with the mind; there should be instant decision, not because the decision is given without thought, but because that decision represents years and years of thought and deep analysis of the principles and relations making up the decision. An impromptu is but the lightning revelation of stored memories instantly and perfectly combined to fit a need.

This process of mental training by analysis, law, and analogy, is not a machine system to take in an ordinary man and to turn him out a genius. It fully recognizes the differences in mental equipment; it does not believe that men are born equal; it does not attempt to make them equal. It aims only to give man power over the mental capital he has, —no matter how little it may be,—to make it instantly available; and it shows him how to ever increase this capital. It teaches man to have all his powers in mental cash; not in checks, notes, or other forms of futures.

This training no "education" gives. If man were to have the most complete education of our schools and colleges, with the additional polish of the best European universities; if he never forgot one single thing he had ever learned: with all this he would not have a trained mind. What, then, of the millions who have less than this? Man, at the end of this period of study, should have either the facts he has studied, or the mental quickness from these facts, to apply to any subject in life. I cannot see how education can escape this

XUM

dilemma. As the mere product of education, merely looking at man from the standpoint of what education has done for him rather than his natural abilities, he has neither. Few men, two or three years after graduating, can give a good, fair ten-minute outline, or résumé, of any subject they have studied—not ten minutes mere talking here and there on the subject, but a clearly formulated grasp of its essentials. They have neither the facts nor the mental strength and quickness to coördinate those facts. Is mere culture and refinement, in itself, a sufficient return for these years of study? The amount of facts necessary to be studied and learned by man is far less than is commonly supposed. The trained mind will absorb and assimilate so much by its mere activity.

The cry comes from Germany, England, and other European countries that the masses are overeducated and unfitted for anything but the professional life. If education were mental training, this condition could never occur. They could not have the mind in "too perfect" a condition, just as it is impossible to have the body "too healthy." A man able to show he had spent these years in mental training, would be valuable in any line of life, and no matter what his duties,—be they humble or great,—he would do them better because of his training. For the future of education there are many hopeful signs in the first rays of dawn of mental training, that already warm and color the horizon. The kindergarten teachings and methods of Froebel, with his wondrous insight into the child mind, and the splendid work of the past few years, is already bearing rich fruit. It seems almost impossible to conceive of any higher educational method for the youngest children than the pure educational theory of Froebel. Occasional failures come from an incomplete grasp of his theory, and from the danger of making the exercises merely arbitrary and mechanical, but these are only slight and incidental, not essential. Color-work, according to the Prang system, in the primary classes, is another step in the right direction; the extension of drawing is another; manual training another; the growing scientific spirit of education, the passing away of examinations, the

broadening of options in studies in our colleges, and the growing, live, liberal spirit of education are all hopeful, and great steps in advance. Many others might be noted if space permitted. Wonderful progress is made in the first year of the child at school, but the progress weakens thereafter, and is not proportionate. Our psychologic discovery, as shown in recent experimental psychology, is far in advance of our educational methods; but every psychologic truth should be translated into the vernacular of educational activity.

Mental training should step in where kindergarten ends. It is not intended to substitute mental training altogether for education, but the modification it would make in the list of studies, and the methods and the term of service, would so materially change our education, that it would be practically a revolution in a very few years. Copernicus said of the system of astronomy in vogue in his time, that its very complexity proved its falsity. So we can say of our system of education. A radical reform must work slowly, and cannot always begin at the bottom, but it should have recognition of its need there. One thing I would suggest is, that we have a Chair of Mental Training in our colleges, entirely distinct from the Chair of Psychology, so well and ably filled in our universities. The duty of such a professor would be to take charge of some such course as here suggested; a course to take, say, four years, and to cover constant conversations and exercises on training the senses, memory, reading, observation, conversation, the study of nature, illustration, imagination, questioning, words, analysis, law, analogy, etc., etc.

The Professor of Mental Training should also be Consulting Physician on the Mind to the students of that college. A student could go to him and say, "I have studied my mathematics faithfully for five weeks, and make no headway. What is the matter with me?" The professor would examine into his methods of study, his standing in other branches; study his mind as a physician would the body, and discover the reason for the inability. It might be a failure to master the first problem, and all that followed was impact,

XUM

not progress; it may be that the student had an excellent eye-memory and studied all his mathematics aloud, taking it in through his weaker sense; in fact, any of a dozen other elements may be the one at fault. This discovered, the individual diagnosis would result in an individual treatment. And so hours and months and years of wasted energy might be spared to students, who force their way through many studies as a gimlet cuts into wood. No matter what be the trouble the student might have in his studies, or in using them, he would receive some practical advice, because the infinite instances can be reduced to a few general phases merely with individual modification.

This training should be part of the normal training of all teachers; and gradually its effect would be felt in a wonderful simplifying and lessening of the list of studies; the leaven of reform would then begin to work in the lower grades, and gradually make itself felt throughout the system. But education claims, "I do not expect students to remember all they have learned; much is given only for mental discipline and training." Then education must face the issue of results; its belief and theory are not followed out. It is in the position of the man of whom his young son said: "Yes, father is a Christian, but he is not working at it much now." When man has given the best hours of his early life,—from five to twenty or twenty-five years of age,—to education, he should surely have the mental quickness and control of his mind for those years. If education cannot justify herself on an accounting for that time; cannot show an equivalent in mental muscle for those years of study, then she is to that degree weak—unequal to her duty, her opportunity. As a mere business matter, man should be able to demand of education a settlement. He should dare to say: "Education, I have given you fifteen years of faithful service to the course of study you have established—what have you given to me?" And education, if she cannot prove she has been equal to her trust, must accept man's criticism; must listen in simple justice to his plea for special training in all that develops him as an individual.

In this series of brief views of the possibilities of mental training by Analysis, Law, and Analogy, I have been forced to reduce panoramas to thumb-nail sketches. It has made a presentation, with everything crowded into the foreground, like the pictures on the Japanese fans, with no proper perspective. Much that may seem visionary and experimental, I have tested and found true in my lectures and individual instances. I have not left the main thought of this subject, to question or to discuss the values of any particular studies or branches. I have not ventured any criticism on the value of lower or higher education in itself, but only sought to show that the training of the mind itself is of supreme, primary importance, and that all true education must give the individual, *at least*, a trained mind. If education gives this, then education can erect upon that trained mind as elaborate a superstructure of as many studies and branches as the human mind will stand. But any system which does not train man's mind, make him an individual, and teach him to think, whether it be in the village school-house on the plains, or in the university with its endowments of many millions, is not equal to its possibilities—is unjust to the individual.

THE BLOOD STAINS ON THE HOLY COAT.

By Émile Gautier.[1]

At the period of history at which we have now arrived science plays so prominent a part in the machinery of society generally, exercises so great an influence over people and things here below, and governs the actions and impregnates the minds of all to such an extent, that the forces of this world have been compelled to take it into account in order that it may not become their enemy. Even religion, which was so long considered, whether rightly or wrongly, as the

[1] Translated and abridged from *Le Figaro* (Paris).

irreducible antithesis of science, will be obliged henceforward to treat it respectfully, and, under certain circumstances, to demand its services and its sacraments. I know nothing, in this respect, more typical or more suggestive than the initiative taken by Mgr. Goux, Bishop of Versailles, in resolving to submit for analysis to profane savants the celebrated seamless coat of Argenteuil, tinged, according to legend, with the blood of Christ.

The Bishop could not have made a better selection than when he fixed upon M. Philippe Lafon and M. Roussel to perform the analysis, for their names were a guarantee that the pious and delicate task would be carried out with due regard to scientific orthodoxy, exactitude, precision, and loyalty. The question which they were requested to solve was this: "What is the exact nature of the spots which stain the garment known as the Holy Coat of Argenteuil?"

It must be admitted that there was nothing particularly difficult in the task. Thanks to ingenious and subtle processes, contemporary chemistry is able not merely to say with absolute certainty whether any particular mark is a spot of real blood, but to tell us its origin, and whether it is the blood of a man or an animal; if of the latter, perhaps even what animal. If we insisted, chemistry would also tell us to what race the man who had shed such blood (supposing it to be human blood) belonged, whether he was in good or bad health at the time, and whether he lived on the mountains or in the plains.

The following well-known tests of the presence of blood were applied by M. Philippe Lafon and M. J. Roussel, who, at the request of Mgr. Goux, Bishop of Versailles, certified that they had made a chemical and microscopical examination of "the Coat of Our Lord," preserved as a holy relic in the treasury of the Church of Argenteuil. Their report was as follows:

I. *Reaction of the tincture of guaiacum and the essence of turpentine.*

After having left fragments of the spots to be examined for several hours in distilled water, we obtained on white filtering paper (or absolutely pure blotting paper) the impression of two spots. After the application to those

spots of a few drops of a mixture in equal parts of the tincture of guaiacum and essence of turpentine, we obtained the green coloration which the blood gives.

II. *Spectroscopical examination.*

The aforesaid spots, after a lengthened maceration in distilled water, gave a solution almost colorless. Our researches with the spectroscope for hæmoglobin, for its derivatives and transformations, ended in negative results.

III. *The search for blood corpuscles.*

We left in contact for several days in artificial serum (composed of distilled water, sea salt, sulphate of soda, and bichloride of mercury), some fragments of spots. In this macerated liquid, after scraping and disintegation of the material composing the coat, we found some red globules of blood unchanged. The number of these elements, their forms, and their dimensions, enable us to attest the presence of human blood in the fluid.

IV. *Formation of crystals of hæmin (blood crystals).*

Another portion of the material was treated with a drop of solution of chloride of sodium in the proportion of 1-1000, and allowed to remain for several days; of course, protected from the air. The saline residue, obtained after evaporation, was submitted to the action of glacial acetic acid, and that process was repeated several times. We always saw, by the aid of a microscope having a magnifying power of 500 diameters, blood crystals, or chlorohydrate of hæmatin, the proper elements and characteristics of blood.

V. *The iron test.*

This method of investigation may be equally utilized to determine the presence of blood. In our attempts we put in parallel execution two series of researches—one on a fragment of the material which was spotted, the other on a fragment devoid of spots. From the two fragments we obtained abundantly and distinctly all the reactions of iron by ferro-cyanide of potassium, sulpho-cyanide, etc. The abundance of the reactions of the iron was too great, in our opinion, to be due to traces of blood. Moreover, these reactions being equal both in the spotted and unspotted parts of the material, we cannot but attribute the iron to the coloring matter with which the garment must have been originally dyed.

CONCLUSION.

To sum up: From the portion of the Coat marked with rust-colored spots, we obtained—

1. A faint green coloration, with the tincture of guaiacum and the essence of turpentine.

2. The revival of the red globules of blood, with the artificial serum.

3. The formation of crystals of hæmin, or of chlorohydrate of hæmatin.

These indications are sufficient to enable us to affirm that the spots examined are actually due to blood—and to human blood. Judging by the whole of our analysis, we presume that this blood is very old.

Drawn up in our laboratory, No. 7, Rue des Saints-Pères, April 10, 1892.

Signed, PH. LAFON,
J. ROUSSEL.

Three affirmative results out of five are surely more than decisive, since, according to the rules of medical jurisprudence, one such result suffices to carry conviction with it. (A. Lacassagne, "Vade-Mecum in médecin expert," p. 65.)

Is it not miraculous that with nothing but watch-glasses, a magnifying glass, some mysterious liquids, and some grains of apparently harmless powder, we can thus accurately determine the presence of blood more than eighteen centuries old?

TRANSLATOR'S NOTE.—M. Émile Gautier need not express so much surprise, as an event which happened eighteen hundred years ago is recent when compared with Egyptian remnants dating six thousand years back, to say nothing of the geological fauna and flora.

SANITARY DELUSIONS.

BY F. L. OSWALD, M. D.

The comparative study of popular fallacies might often seem to justify the remark of the cynic Heine, that the inaccuracy of the various sciences bears an exact proportion to the degree of their practical importance.

The prevailing errors respecting the motion of distant stars and the composition of useless minerals have been corrected with indefatigable assiduity, while the most preposterous delusions concerning the origin of religions and the health-laws of nature have been either ignored or tacitly encouraged.

The necessity of observing a compromise between the might of truth and the power of established shams cannot wholly explain that discrepancy, and the persistence of sanitary fallacies seems to be rather an after-effort of the anti-physical dogmas which for so many hundred years depreciated the importance of bodily welfare. Neither spirituous nor spiritual quacks would, for instance, be apt to object to an investigation of the alleged facts supporting the current notions on the origin of "cold," though the truth or error of

those theories is a question of almost constant personal interest to millions of our fellowmen, and though their absurdity could be demonstrated by the evidence of unequivocal experiments.

"I shall not try to explain why catarrhs are caused by damp rather than by wet clothes," Benjamin Franklin wrote a hundred years ago, "because I doubt the fact, and suspect that the causes of respiratory affections are totally independent of dampness as well as of cold."

Why has the suggestion of that shrewd surmise been so little heeded? Amateur astronomers have traveled thousands of miles, and braved the vicissitudes of wind and weather, to observe a transit of Venus and verify the conjecture of a trifling error in the computed distance measures of the planetary system; why could no lover of sanitary science, or of the human species, afford to brave the inconvenience of a brief exposure to a low temperature, or damp and cold air currents, in order to test the pleas of a delusion which in all probability sends an annual average of two million human beings to a consumptive's grave? In still plainer words, have we a right to wrangle about the "Aramaic evidence of the Post-Pauline miracles," while an investigable problem of life and death import to a third part of the human race remains unsolved?

Hunters, herders, and teamsters, exposed to all the thermal contrasts of a fitful climate, enjoy an almost constant immunity from troubles that affect the operatives of well-warmed factories and the tenants of weather-proof city dwellings. Consumptives, who cough away their lives in stove-heated sick-rooms, recover in a highland camp of the frosty Adirondacs. The sanitarium of a South German country parson invites public examination of statistics that prove the cure of lung patients who have been made to walk barefoot in dew-drenched grass. Conductors and pilots are none the worse for their daily exposure to the most violent cold draughts. Camping soldiers who have got rid of so-called chronic lung-affections almost invariable experience a relapse on their return to barrack-quarters. Is it possible to

mistake the significance of these facts? Do they not prove beyond the shadow of a rational doubt that catarrhs are not caused by cold outdoor air, but exclusively by the impurities of warm indoor air?

Like the germs of cholera and yellow-fever, lung microbes thrive in warm miasma, while their development is almost instantly checked by the influence of pure, cold air, which is, in fact, as grateful to our respiratory organ as fresh water is to the palate; and Dr. Graham, in his magic dormitory filled with perfume and sweet harmonies, cannot have slept sounder than a Michigan lumberman in his winter camp that admits the keen night air from all quarters of the compass, but defies frost with a triple stratum of thick woolen blankets. It would be decidedly worth the costs of the experiment to collect a score of catarrh-troubled tramps in the ill-ventilated calaboose cells of our American railway centers, and conduct them to a camp of that sort, where their horror at the prospect of work would be speedily allayed by the offer of three free meals and a dollar a day as an offset to the risk of a free bivouac on the backwoods plan. If, within a week, every one of the twenty patients should have got rid of his catarrh, and if that catarrh should in every case reappear within two days after the return of the convalescent to an extra warm calaboose cell, the result ought to be accepted as a conclusive confirmation of Franklin's conjecture, as well as of the fact that for more than a thousand years the most effective cure of lung-disorders has been mistaken for their cause.

A similar experiment would establish the extravagant absurdity of the current belief in the perils of a drink of cold water in the heat. As Herbert Spencer observes, it is time to rid ourselves of the nightmare belief in a universe so diabolically arranged that its evils are attractive and its blessings repulsive (an idea as common as other echoes of mediæval antinaturalism). We should learn to trust our welfare to our sanitary intuitions, and feel sure that a draught of Nature's own beverage *cannot* be injurious at a time when the voice of instinct calls loudly for refrigeration, and that there is no tenable physiological pretext for the advice to "wait till you

are cooled off." We might as well admonish a tired child to keep out of bed till it had overcome its weariness. During a summer campaign in the highlands of Southern Mexico I have again and again seen hundreds of panting soldiers kneel down at the brink of a cold Sierra brook and quench their thirst without stint and without the least misgiving of health-impairing consequences. On one occasion we had failed to find a drop of good water on an uphill march of fourteen miles during the warmest eight hours of a sultry midsummer day, and when at last a turn of the road brought us in sight of a rivulet, fresh from its rock-spring, some two hundred and ninety out of three hundred soldiers—French, Austrians and Mexicans—flung themselves down and drank and drank till the feeling of actual repletion forced them to desist. We had still five miles to camp, and I availed myself of the opportunity to question the men—not in the style of a medical Rhadamanthus, but as a chat-loving, sympathetic sharer of their toils. Had they experienced any disagreeable effects from that horse-dose of cold water?

"Disagreeable? Indeed, no; it seemed to put ten dollars' worth of new life in my bones."

"I never felt so well since that cold swim in Lake Lerma; it braced me up for the rest of the day."

"If you ask my opinion, I should say it would be worth while to climb those fourteen miles over again for the sake of a drink like that."

Only one man admitted that the first gulp of cold water had given him a sort of congested feeling near the root of the nose, a transient sensation sometimes experienced by hasty ice-cream eaters. The belief in the deadly effects of cold drinks is certainly not founded on experience, but partly on the superstitious dread of cold, in all forms; partly, also, on the idea that a refrigerating draught, being extra pleasant in warm weather, must *therefore* be extra dangerous. "Whatever is pleasant is wrong," was for centuries the motto of monastic moralists.

Practical experiments might also demonstrate the truth that "poison" and "stimulant" are interchangeable terms;

and that the stimulant habit is wholly abnormal, and under all circumstances prejudicial to physical and moral health. Poisons are either repulsive or insipid. Arsenic, sugar of lead, and antimony, belong to the latter class. To the first-born children of earth, certain mineral poisons were decidedly out-of-the-way substances, against which Nature apparently thought it less necessary to provide special safeguards. But, though less repulsive than other poisons, such substances are never positively attractive, and often (like verdigris and potassium) perceptibly nauseous. Vegetable poisons are either nauseous or intensely bitter. Hasheesh is more unattractive than turpentine. Opium is acid caustic. Absinthe (wormwood extract) is as bitter as gall. Instinct resists the incipience of an insidious second nature.

But that instinct is plastic. If the warnings of our physical conscience remain unheeded; if the offensive substance is forced again and again upon the unwilling stomach; Nature at last chooses the alternative of compromising the evil, and, true to her supreme law of preserving life at any cost, prolongs even a wretched life by adapting the organism to the exigencies of an abnormal habit. She still continues her protest, in the feeling of exhaustion which follows every poison-debauch, but permits each following dose of the insidious drug to act as a temporary reinvigorant, or at least as a spur to the functional activity of the organism; for the apparent return of vital vigor is, in fact, nothing but a symptom of the morbid energy exerted by the system in its efforts to rid itself of a deadly intruder, and each new application of the stimulus is as regularly followed by a depressing reaction.

And only then the slave of the unnatural habit becomes conscious of that peculiar craving which is entirely distinct from the promptings of a healthy appetite; a craving uncompromisingly directed toward a special—once repulsive—substance; a craving defying the limiting instincts which indicate the proper quantum of wholesome foods and drinks; a passion which each gratification makes more irresistible. And every poison known to modern chemistry can become

the object of that specific craving. Entirely accidental circumstances, the accessibility of special drugs, imitativeness and the commercial intercourse of special nations—the mere whims of fashion, and the authority of medical recommendations—have often decided the first choice of a special stimulant, destined to become a "national beverage" and a national curse. The contemporaries of the Veda-writers fuddled with *soma-wine*, the juice of a narcotic plant of the Himalaya foothills. Their neighbors, the pastoral Tartars, get drunk on koumiss, or fermented mare's milk, an abomination which in Eastern Europe threatens to increase the list of imported poisons; while opium is gaining ground in our Pacific States as fast as lager beer, chloral, and patent "bitters" on the Atlantic slope. The French have added *absinthe* to their wines and liquors; the Turks, *hasheesh* and opiates to strong coffee; North America has adopted tea from China, coffee from Arabia (or originally from Ceylon), tobacco from the Caribbean savages, high wines from France and Spain, and may possibly learn to drink Mexican aloe-sap, or chew the coca leaves of the South American Indians. Arsenic has its votaries in the Austrian Alps; cinnabar and acetate of copper victimize the miners of the Peruvian Sierras; the Ashantees are so fond of sorghum beer that their chieftains have to keep special bamboo cages for the benefit of quarrelsome drunkards. The pastor of a Swiss colony, in the mountains of Oaxaca, told me that the highlanders of that neighborhood befuddle themselves with cicuta syrup, the inspissated juice of a kind of hemlock, that first excites and then depresses the cerebral functions, excessive garrulity being the principal symptom of the exalted stage of intoxication. A decoction of the common fly toad-stool (*agaricus maculatus*) inflames the passions of the Kamtchatka natives, makes them pugnacious, disputative, but eventually splenetic (Chamisso's *Reisen*, p. 322). The Abyssinians use a preparation of durra corn that causes more quarrels than gambling. It is a favorite beverage at festivals, and is vaunted as a remedy for various complaints, though Belzoni mentions that it makes its votaries more subject to the attacks of the

Nile fever. According to Prof. Vambery, the Syrian Druses pray, though apparently in vain, to be delivered from the temptations of foxglove tea.

THE PENDULOGRAPH.

By Rev. John Andrew, Belfast.

"He that built all things is God."

Every one who looks at a pendulograph is ready to confess that it is "a thing of beauty;" but every one is also ready to ask, "But what is it?" In explaining a pendulograph, we must trace it to its law, and point out its place in nature.

The motions of the stars in their courses, the swinging of pendulums, and the vibrating of musical instruments, are all under one great law—the law of GRAVITATION. If the stars in their courses through the heavens, by a great pen attached to them, were to leave a line behind them written on the pages of space; or if musical instruments would in their rapid vibrations record themselves, and by a fine pen attached to them write a picture that would remain for the delighted eye after their sounds had died away upon the delighted ear—these drawings, great and small, would be of the nature of pendulographs.

The wondrous analogies between the harmonies of different reaches of creation, which pendulographs demonstrate, and which Mr. Keely's researches in the realms of acoustics are drawing so deeply upon, prove that the great builder, God, works throughout the universe under one law, the law of harmony, and that He Himself conceived the varied forms in which all things are built. His creative conceptions are marshalled in great groups. In each group a vast variety of forms are further marshalled in lesser hosts,—God is "the Lord of Hosts." "He hath made His works to be remembered." "The heavens and the earth were finished, even all the *host* of them." Constellations of

stars fill the deep of space. Solar systems are formed and arranged round warming suns. Orbs which are worlds, one of them at least we know garnished with objects useful and beautiful, which we first see as great kingdoms of objects, mineral, vegetable, and animal; each kingdom further marshalled under great *types* of structure; these still further grouped in *classes;* these arranged in *families* with family features; and these disposed in *orders*, *genera*, and *species;* each individual creature being of some distinct species, belonging to some genus, member of some particular family, disposed in some order; and the various orders all grouped in classes under great types of structure and pertaining to one kingdom or another of creation. Were it not for this creative classification of the Lord of Hosts we should stand bewildered, and our memory baffled in the midst of the multitudinous variety of the natural objects which surround us, and in which the Creator has presented His thoughts to us.

It has been the work of scientific naturalists to seek out and exhibit this order of nature. Man's mind, being the offspring of God, works after the same fashion to find out the structure and plan on which all things are built. Man himself also works after a similar manner, and his works arrange themselves by the law of his mind and creative faculty in certain great groups. As God has presented His thoughts in His works, so man presents his in the same way; everything he does is representative of his thoughts, which, either by words or works, are symbolized and presented to the view; by words of history, poetry, philosophy, or description; and by works of art useful and fine.

Belonging to the works of *fine art* are pictures, statuary, and music; under pictures come paintings, pen-and-ink sketches, etchings, engravings, photography, lithography, etc.; under pen-and-ink sketchings comes pendulography as one of its orders, with genera and species according to their kind. A pendulograph, however, differs from other pen-and-ink sketches; other pen-and-ink pictures are by the art of man; a pendulograph is mostly by the art of God, it is a work-

of Nature. The pendulographer *tunes the ratio*, for by the various ratios of the pendulums are genera produced; and he *adjusts the penstand* by which the species of those genera are developed, for the penstand determines the species; and he starts the pendulums; things being thus adjusted, all the rest is left to the great operation of gravitation, and the picture is built up by a natural action which may not be interfered with; the least touch of man would spoil the work.

Jacques Cassini, an eminent astronomer of the royal observatory of France in the last century, mapped out the course of *Venus* in relation to the earth. From month to month he noted the relative attitude of the planet through the years from 1708 to 1716, a period of eight years, when it had returned to the same place. Cassini then drew an imaginary line from month-place to month-place, and thus produced a most interesting planetograph, written as it were in space. He did the same for the other planets known in his time, and thus produced a portfolio of celestial pendulographs, drawn by these mighty pendulums in their relative movements under the law of gravitation. Cassini's picture of the position of *Mars* relative to the earth was continued through the months from 1708 to 1723, a period of fifteen years, when it returned to the same place; that of *Mercury* was continued from 1708 to 1715, a period of seven years; for *Jupiter*, the period was from 1708 to 1720; and for *Saturn*, from 1708 to 1737, a period of twenty-nine years, in which times these planets wrote their pendulographs and returned *to nearly the same places*, not quite the same. These figures followed through a period, lengthened out for a great number of generations, would show that the pictures so written are SPIRALS, and so are all the pen-and-ink pictures written by oscillating pendulums.

Pendulums, silently swinging, come in between the grand movements of the stars and the quick vibrations of musical instruments; and they are so near, compared with the stars, and so slow, compared with musical instruments, that we can easily follow their movements; and, in fact, looking at the slow-moving pendulums swinging the harmonies is like looking through a magnifying glass at the vibrating strings, and

seeing all the mysteries of their motions that are far too quick for the unaided eye; and by attaching a pen to them we can make them portray those movements. This is a pendulograph.

A system of pendulums tuned to swing the various ratios of the musical scale forms a SILENT HARP *of extraordinary interest.* A pen placed by means of a universal-jointed arrangement between any two pendulums of this silent harp so as to be moved by a blend of their various motions, writes, with all the precision of gravitation, a portrait of the chord which two corresponding strings of a sounding harp would utter to the ear. *This spiral writing is a pendulograph.*

The pendulums may be of half-inch wood—hickory or any straight wood; forty-nine inches long; suspended on knife-edges; eight inches of the rod being above the point of suspension. This upper part will oscillate in the same time as the under length; but, of course, in the opposite direction, and is intended to carry the pen-arms. The suspension should be in notches in a table, and running at right angles. The pen-arms are joined to the pendulum top with ball-and-socket joints; the other ends carrying tubes to hold the pen; the inner tube holding the pen should move easily but steadily in the other tube, and these tubes should stand in the angle of 90°. The pen should be made of a glass tube with a fine polished point; the ink drawn into it by suction. A little table must be placed under the pen to carry the paper which is to receive the writing. The bulbs of the pendulum should be, say, each six pounds weight, and pierced so as to let them slide up and down on the rods. The rod having the bulb placed at the foot may be called the statical pendulum, while the other has the bulb removed to any point, so as to allow the perfect tuning of it in relation to the statical pendulum.

It is exceedingly interesting to watch the pendulums when once their mass has been tuned to any ratio, say 4:5 or 3:5 or 5:6, and see their undeviating obedience to the ordinance of gravitation; that wondrous action of the all-upholding hand of Him who built all things. It is also very interesting to watch the pen, by the blended movements, diverse yet

harmonious, of the two pendulums, quietly but with fearless sweep writing out the picture of this harmony; and if undisturbed there are no mistakes.

Let the paper on which you are to write be placed on a small circular table, which can be turned on a pivot under the pen; and have the table marked as a mariner's compass, with radial lines running north and south, east and west, and to twelve intervening points. Have a standard mark near the table, to which the points of the compass can be successively and accurately set. Have also a series of concentric circles drawn round the center of the table, on which, as well as on the radial lines of the compass, the pen can be placed by shifting the table under it. This we call the *penstand;* which, next to the ratio to which the pendulums are tuned, is the most important part of the adjustment; for from this penstand the various *species* of the *ratio-genus* take their rise. The time which the pendulums take to return to the starting point we call a *period* of the ratio; each successive period is a little smaller than the preceding one, till the pendulums stand still; so every pendulograph is a *spiral line* of either a simple or more complex character, according to the ratio to which the pendulums are tuned. If a figure is to be repeated a number of times for a composition, in the way of creating new designs, or illustrating the development of species, the lines of the compass must be turned against the standard mark carefully in succession, according to the number of figures intended to be built into the composition; each figure must have the same number of periods, the sweep of the oscillation must also be the same, else one figure will be larger than another and the symmetry of the composition will be spoiled. If all these directions be carried out, it will be a source of interest and delight to see the specific forms which the same ratio-genus, the same color of ink, the same number of figures, and the same number of periods in each figure will produce. Each new penstand will give a new species, or design. The resources of the instrument, if the artist be inventive and expert, will excite wonder and admiration. The *ratio* is the *genus*, and the *penstand* is the *species* in this

domain of nature. Many *varieties* of the same species may be obtained by color of ink, number of figures, number of periods in each figure, and range of oscillation. Every series of species should be headed by a figure of the ratio, which is the genus to which they all belong; and this single figure should be written with the same tuning as that used throughout the series.

If the table be mounted on a clock-work movement, by which it may be carried steadily round while the pen is busy writing any ratio picture, the writing will be spread out; every successive period, instead of being written within the preceding one, will be written on new ground outside, and many beautiful varieties of the same ratio and penstand may be done in this way, in which it is sometimes very hard to trace out the ratio, so unlike are the figures to those written on the still table.

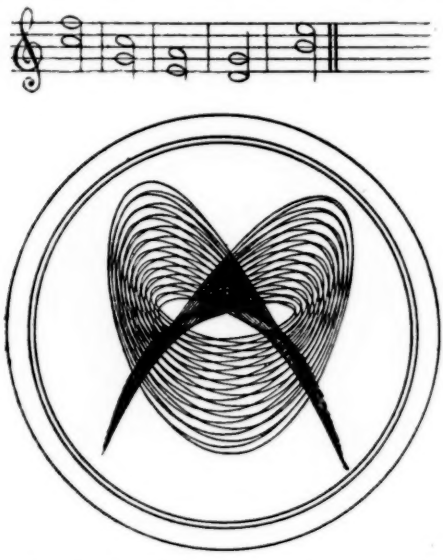
The ratio of 4 : 5 is one of formosal beauty. Dividing the compass of 360° by 2, the octave number, till in the fourth octave we have $22\frac{1}{2}°$, marking sixteen points of the compass; giving the pen this standpoint from point to point, the first penstand being due east, and on a concentric circle of one and one-half inches diameter; then keeping on this circle, but for every new composition shifting the penstand $22\frac{1}{2}°$, we have a series of sixteen species;—the oscillation should have a sweep of six inches at the point of the pendulums. The figure may be written twelve times round the compass, and each figure of five periods; this makes a composition of three hundred oscillations; the sixteen penstands being each treated in the same way; the same pen and ink, the same number of figures on the compass, the same number of periods in each figure, the same sweep of oscillation, the only difference being the *penstand;* the result is sixteen species, each structurally differentiated, each a true and permanent species, "whose seed is in itself after its kind;" and a most interesting and beautiful portfolio is originated.

Any naturalist finding in nature any one of these sixteen forms, would be bound both by the *structure* and the *embryology* to define and arrange it as a species. And here is an

illustration of the permanence of species; for if this should be written for a thousand years, the embryological element of ratio, and the structural penstand remaining the same, the species would still be produced unchanged, with no tendency to become anything else.

With regard to the analogy between music and pendulography, it is very remarkable how close it is. The tuning pendulum, when so placed as to oscillate in the ratio of 2:3, which is the ratio of the perfect fifth, F–C, C–G, G–D, for example; and when this ratio is perfectly tuned, and the pendulums smoothly started together, the pendulograph will be to the eye a picture analogous to the chord of the fifth in the ear, very simply beautiful. And so through all the

The ratio of 3:4 occurs five times in the vibrations of the musical system.



chords of the musical system; and through all its discords as well. In confirmation of the closeness and truth of this analogy, it will be found that all the discords which belong to the system of music, and which have very complex ratios,

such as 45 : 64, produce such intricate pendulographs that they are as disagreeable to the eye as those discords are to the ear. But nature has so ordered that these less harmonious chords should have few places in the system, while the more agreeable and welcome occur frequently; 16 : 27, 20 : 27, 27 : 32, 27 : 40, 32 : 45, and 45 : 64 occur only in one place each; 5 : 9 and 8 : 15 in two places each; 5 : 8, 4 : 5, 3 : 5, 5 : 6 and 9 : 16 occur in three places each; while 2 : 3 and 3 : 4 occur five times each; and 2 : 1, the octave, occurs everywhere. The discords are the "*bitter herbs*" which give relish at the feast of harmony. Now, when all these ratios are tuned and written, the pictures correspond in the eye to these cords and discords.

If this article should stir up a desire to develop this art of PENDULOGRAPHY, whether as an analogous and illustrative domain of nature in the interest of SCIENCE, or as a new resource of beautiful and very varied designs in the interest of ART, the author will not have wasted his time in writing it, and will be glad to give help for a start to any one who might determine to pursue it.

WHAT IS SCIENCE?

COMPILED BY MRS. H. O. WARD.

Science is a lucid madness occupied in tabulating its own hallucinations.

LOUIS FIGUIER.

Hitherto the progress of science has been slow, and subject to constant error and revision. But as soon as physical research begins to go hand in hand with moral or psychical research, it will advance with a rapidity hitherto unimagined, each assisting and classifying the other. JULIAN HAWTHORNE.

Underneath all the various theories which are only created to be destroyed; underneath all the hypotheses which one century regards as disclosing the secret mechanism and hidden spring of the universe—and which the following century breaks to pieces as children's toys—may be recognized the slow progress, slow but incessant, of mathematical physics.

DUHÈNE, "REVUE DES DEUX MONDES."

"EACH AGE ANSWERS THE NEED OF ITS OWN TIME."

Edward Carpenter, in his "Criticism on Modern Science," says: "Science, like an uninformed school-boy, is most

definite and dogmatic just where actual knowledge is least. Some day, perhaps, when all this showy vesture of scientific theory has been quasi-completed, and humanity is expected to walk solemnly forth in its new garment, for all the world to admire—as in Andersen's story of the 'Emperor's New Clothes'—some little child standing on a doorstep will cry out: '*But he has got nothing on at all,*' and, amid some confusion, it will be seen that the child is right."

This forecasting of the fate of what has been called "phantom-science," is about to be realized; but it is no child crying out that the phantom has got no clothes on. It is science herself, as defined by Walker, "Certainty grounded on demonstration;" by Chambers, "Systematized knowledge, truth ascertained;" better still by Ganot, "A knowledge of the laws that govern the universe;" for it is this department of knowledge which is about to be made known to, and understood by, all men who are able to comprehend it.

Religious science now leads the way to that knowledge of what man is, and of the true relation to each other of all his faculties, which alone constitute her legitimate realm, and over which she has reigned, in all human societies that have left the savage state behind them, until our age.

But what is religious science?

Tolstoï answers that "it is the sum of all human information as to what relates to the destiny of man, and to the true welfare of each man and of all men." He continues: "There are innumerable quantities of subjects to which science may be applied; but the one science that determines the importance of other sciences, is the knowledge of what constitutes the welfare and destiny of all men. Without this knowledge, all other arts and sciences become a pernicious amusement, and to this subject true science has always given, and must always give, the first place.

"Mankind has been living long, and men have never been without a science relative to their welfare. To a superficial observation, this science appears to be different with Buddhists, Brahmins, Hebrews, Christians, the followers of Confucius, and those of Laotse; though one need only to reflect

on these various teachings in order to see their essential unity; and now of a sudden it turns out that modern 'men of science' have decided that this very science, which has been until now the guide of all human information, is in the way of everything; and this denial of knowledge they call science!

"All that has been done in this direction from the beginning of the world by the greatest intellects of mankind are trifles, and no longer have weight. According to this teaching you are a cell of an organism, and the problem of your reasonable activity consists in trying to ascertain your functional activity. In order to ascertain this, you must make observations outside yourself, and you must believe everything that people with the diploma of infallibility tell you.

"Looking back, we see that during thousands of years, from among thousands of millions of men who have lived, there came forth a few like Confucius, Buddha, Solon, Socrates, Isaiah, David, and others. Now-a-days, there is a trade-corporation of learned men, and they prepare, by an improved way, all the mental food which is wanted by mankind. They have prepared such a variety that there need no longer be any remembrance of the old producers; not only of the very ancient, but of more recent ones. All this, we are told, was the activity of the theological and metaphysical period, and the true mental activity began some fifty years ago. But when men are really called to serve others by mental activity, they will have to suffer in performing this labor; because it is only by suffering that spiritual fruit is produced. Self-denying and suffering are their portion; because their object is the welfare of humanity. It was not in vain that Christ died on a cross; it is not in vain that sacrifice and suffering conquer everything."

Tolstoï gives no rational way of deliverance from the evils inflicted on mankind by false teaching and error; closing his book ("What to Do") with these lines: "Women who fulfil their mission are those who prepare new generations of men in forming public opinion. Therefore, in the hands of these women lies the highest power of men's salvation

from the existing and threatening evils of our time. Yes, mothers, women, in your hands, more than in those of any others, lies the salvation of the world."

Here he leaves us, seemingly unmindful of the fact that "God has entered human life, and by orderly steps is working out His grand designs;" choosing His instruments Himself to work out these designs with Him.

It is a relief to turn from Tolstoï's pessimistic pages, and futile suggestions "What to Do," to Carpenter's "Forecast of the Science of the Future," wherein he leads us to see that, as there is no invariable and absolute datum on the fringe of humanity, no definable flying atom on which to found our reasonings; and as modern science, considered as an actual representation of the universe, falls miserably to pieces in consequence; it may be possible that science has made a mistake in the direction in which she sought for her datum, and that she may yet find it, if she looks for it, in the very centre of humanity, instead of in its remotest circumference. "In attempting to solve the problem of science by the intellect alone, a radical mistake has been made, which *could* only land us in absurdity. In searching for a permanently valid and purely intellectual representation of the universe, science has been searching for a thing which does not exist," writes Carpenter, proceeding to show that in the individual feeling precedes thinking, that thought is the expression, the outgrowth, the covering of underlying feeling; and that in the great life of man as a whole, as in the lower life of the individual, his continual new birth and inward growth cause his thought-systems also to change continually and to be replaced by new ones.

"Like the bud-sheaths and husks in a growing plant or tree, they give form for a time to the life within, then they fall off; the husk having prepared the bud underneath, which is to throw it off. So the thought has prepared and protected the feeling underneath, which, growing, will inevitably reject it; for when a thought has been formed it is ready to fall."

Divining, as it were, what religious science is now ready to make known, Carpenter asks, "Is it possible that here, in the very centre of humanity, if we could penetrate, blazing like a sun if we could only see it—and the sun is its allegory in the physical world—there exists within us absolutely such a thing; *the one fact in the universe, of which all else are shadows*, to which everything has relation, and around which, itself unanalyzable, all thought circles and all phenomena stand as indirect modes of expression?"

"The light shineth in darkness and the darkness comprehendeth it not."

This light, "blazing like a sun," ushers in the dawn of a new era for humanity; for "a fuller revelation of revelation" has been vouchsafed to man, fitted to his growth and to the growth of the tree of knowledge. One by one the bud-sheaths and husks will fall off, rejected; for in this "era of harmony," foretold by prophets and apostles, the work of evolution will continue on a far more grand and more rapid scale than has been possible heretofore in the history of our race, while the light shining in darkness was incomprehensible to it.

"To be pioneers in a new order of things," says John Sartain, "is a privilege to be valued, and so also is it to live just in this period of the earth's long history. The discoveries of science follow each other in rapid and most bewildering succession; and each new achievement is seen to be a stepping-stone to further acquisitions. More has been accomplished during the present century to give man complete mastery over this planet than in all the countless centuries of the past. He now grasps the key that will unlock the many-leaved Book of Nature; on whose pages are inscribed, in everlasting letters by the very finger of God, the unchanging laws of the universe. * * * * * *

"Man is a double generation, divine and human. But behind and through all is the invisible, subtle spirit that moves visibly in all bodies, and has its seat in the Divine Will. Mind, pervading all, and through and in all the universal creative spirit, known by various names in various climes."
—("The Four Elements.")

The law of sympathetic association is the key that has unlocked "The Book of Nature;" for it is the operation of this law which governs the universe. Its discoverer holds himself in readiness to impart his knowledge, whenever "men of science" are ready to leave their laboratories and witness his demonstrations of this controlling power.

So far, they stand aloof, "all, with one accord, making excuse;" researching their environments, boarding air-ships anchored to the earth (to which they must remain anchored so long as they are constructed on principles which ignore the laws governing our "environment"), and too often occupying themselves in efforts to prove that the soul is the mere product or offspring of organization; that both grow up to maturity together, existing in indissoluble union, and perishing at one and the same time, thus giving ground to the general belief that science and religion are antagonistic. If they have been so, hitherto, it is religion that will conquer, and stand holding the olive branch and the cross over her prostrate foe; for religion and science, *in virtue of their natural affinity, have met*, in the brain of one man of genius, and the world will get what it needs and cries for; not a new religion, but such overwhelming demonstration of the "inner light" in man, of the immortality of the soul, that not one skeptic, not one materialist, will find standing room on the face of the earth, when science and religion have been made known as one. The premature formation of theories and systems of science in the past, which are now inadequate to explain all the phenomena of nature, is in part the cause, why, when the announcement was made in 1889 by men of science that a force of nature had been discovered which overcomes gravity and neutralizes weight, physicists rejected the proffered proof. Not because they were able to demonstrate this information to be unworthy of credit, but because it was irreconcilable with their present knowledge and their preconceived notions of nature's operations.

"Is it possible," asks Carpenter, "that the phenomena of chemistry only find their due place and importance in their relation to living beings and processes, that the phenomena

of vitality and the laws of biology and zoölogy, evolution included, can only be explained by their dependence on selfhood, both in plants and animals? That political economy and the social sciences (which deal with men as individual selves) must, to be understood aright, be studied in the light of those great ethical principles and enthusiasms, which to a certain extent override the individual self; and that, finally, ethics" (now founded upon selfish greed) "or the study of moral problems, is only comprehensible when the student has become aware of a region beyond ethics?"

The key of "Nature's Many-leaved Book" opens up this region to searchers after truth; but, as has already been said, our learned men have refused to accept the key, for the reason that they are too much engrossed with their various researches into the nature of the environments of man to waste their valuable time on his destination and his inner consciousness of that destination. "If we are to use science," continues Carpenter, "as a minister to the most external part of man, to provide him with cheap boots and shoes" (to which list should be added explosive substances and smokeless powder), "then she is right to seek her absolute datum in his external part, and to take *the foot* as her first measure. But if she wants to find a garment for his inner being, or rather one that shall fit *the whole man*, to wear which will be a delight to him, and as it were a very interpretation of himself, it seems obvious that science must not take his measure from outside, but from his most central principle.

"Under the present *régime* (the foot *régime*), the universe is usually conceived of as a medley of objects and forces more or less orderly and distinct from man; in the midst of which man is placed—the purpose and tendency of his life being "adaptation to his environments." To understand this, we may imagine Mrs. Brown in the middle of Oxford street. Omnibuses and cabs are running in different directions; carts and drays are rattling on all sides of her. This is her environment, and she has to adapt herself to it. She has to learn the laws of the vehicles and their movements; to stand on this side or that; to run here and stop there; conceivably

to jump into one at a favorable moment; to make use of the law of its movement and so get carried to her destination as comfortably as may be. A long course of this sort of thing adapts Mrs. Brown considerably, and she becomes more active, both in mind and body, than before. That is all very well. But Mrs. Brown has a *destination;* (indeed, how would she ever have got into the middle of Oxford street at all if she had not had one?) and the question is, "What is the destination of man?"

The present theory seems to be that "by studying your environment," you will find out; that is, by investigating astronomy, biology, physics, ethics, etc., you will discover the destiny of man, but this is about the same as saying that by studying the laws of cabs and busses sufficiently you will find out whither you are going. These are ways and means. Study them by all means, that is right enough; but do not think they will tell you where to go. You have to use them, not they you. In order, therefore, for the environments to act, there must be a destination; for notwithstanding the prevalence of "*the foot régime*," there is in man a divine consciousness as well as a foot consciousness. That there are in us phases of consciousness which transcend the limit of the bodily senses is a matter of daily experience. That we perceive and know things which are not conveyed to us by our bodily eyes, or heard by our bodily ears, is certain; may there not then be in us the makings of a perception and knowledge which shall not be relative to this body, which is here and now, but which shall be good for all time, and for all stages of existence elsewhere? The doctrine of the "inner light," taught by the ancients and adhered to still by the Quaker denomination, gives the correct explanation of the origin or seat of this consciousness. It is "the Spirit[1] of Truth" which leads into all truth those that look to it for guidance, unfolding to the enlightened eye of the soul the mysteries of nature and of the highest science: the science of religion.

"If this divine consciousness, this 'illumination,' this 'inner light,' really exists in man, then," says Carpenter, "an

[1] St. John, 16: 13.

exact science is possible. Short of it there is only a temporary phantom science." "Whatever is known to us by consciousness (direct)," writes Stuart Mill, in his "System of Logic," "is known to us beyond possibility of question." This question Carpenter modifies by saying, "What is known by our local and temporary consciousness is known *for the moment* beyond possibility of question; what is known by our permanent and universal consciousness is permanently known beyond possibility of question. Physics has been unable to discover the elements of motion, and has abandoned as fruitless the research of the moving power, the vital principle, possessed by man, without which his various organs would be utterly useless. Physiology, too, is ignorant of what *life* really is, yet pretends to explain its phenomena; and psychology, not knowing in what manner the spiritual faculties are united to the organization, is compelled to investigate the operations of the intellect as if they were performed altogether independently of the body; whereas, they are only manifested, in the ordinary state of existence, through the intermediate agency of the corporeal organs."

"You can not mix up physics and psychology," said a physicist, not many years since, who now sees that no system of science is complete that excludes all consideration of manifestations, which, as phenomena of nature, are therefore a fit subject of philosophical investigation. "What should we think," asks Colquhoun, "of the wisdom of that man who, in attempting to communicate an adequate idea of the operations of the steam-engine, should content himself with a mere description of its wheels and levers, and cylinders and pistons, keeping out of view the moving power—the steam, and ridiculing all investigation into the nature, application, and phenomena of this power?"

James B. Alexander, in his book on "The Dynamic Theory," says, "the advancement of the present generation has been greatly assisted by its partial emancipation from the dominance of the past, with its essentially vicious metaphysical methods. The study of dynamic agencies, and the inferences made, justified by the inductive method of considering

them, furnish us with all the real knowledge that we possess. The dynamic theory, by showing the connection between the external stimulation and the internal sequel in mental action, proves that both of them belong to the same class of physical motion. A similar consideration extended to other branches of physical phenomena, shows them all to be derived from a common stock, and that, finally, we must consider all energy as one."

The object that Mr. Alexander has had in this volume, he tells his readers, is "to point out that all organisms, instead of being hand-made, and purposive, are machine-built machines; and, when built, are operated by forces outside of themselves." In other words, he demonstrates the separate existence and independent activity of the soul of man, as well as its powerful influence over the corporeal organism, and that it governs, instead of being governed by, the body.

From the earliest dawn of science, the apparently interminable controversy between the materialists and the spiritualists has been a great stain upon philosophy. The term physics is derived from a Greek word signifying nature. The materialists limit nature to matter and mechanism; but the phenomena of spirit are as much a part of nature as are those of matter. It has been left for this age to reconcile their differences; proving *by mechanical demonstration* the power of mind over matter; and making clear, to the philosophical mind, how cosmical law works in linking all our environments to the divine: one great law, in the proper completion of its action, controlling every minute law governing the plane of matter, and with equal exactitude the plane of spirit. Kepler was able to penetrate so far into the causes of the planetary movements, as to acknowledge that in them was hidden the secret of the element of motion and of force. "He was persuaded," writes Professor Bowne, the Dean of Boston University, "that the full discovery of these mysteries was reserved for the next age, when God would reveal them to man."

The one law which nature works under, in all her operations, is the pivot upon which all turns; providing, as it

does, for the free and the forced, for mind and matter, and placing them in a scientific relationship with one another; the law of "sympathetic association." This law Dr. Macvicar called "The Cosmical Law;" "because to it alone, ever operating under the eye, and fulfilling the design of the Great Creator, who is always, and in all places, immanent to His creation, an appeal is ever made;" but to demonstrate how cosmical law is realized by a dynamic apparatus, he says, "except in a very few steps at first, wholly transcends our powers and belongs not to our day."—("Sketch of a Philosophy," 1868.) With Buckle, Macvicar affirms that "as yet we have no sure basis for knowledge, and that science must wait for the only solid foundation; until some discoverer, some 'Newton of the Mind,' has associated his discovery with the laws of the mind that made it, and demonstrated, in a *mécanique céleste*, the governing laws of mind and matter."

The conditions imposed by Kepler, Macvicar, and Buckle, are now fulfilled; the secret of planetary suspension has been discovered; the discovery *is* connected with the laws of the mind that made it; *the mécanique céleste is completed in a dynamic apparatus which demonstrates how cosmical law is realized;* and the "Newton of the Mind," whom Macvicar anticipated, is the founder of a system of vibratory physics, which gives to commerce the navigation of the air, and to science a knowledge of the law that governs the universe; the law of "sympathetic association."

To triumph over matter and render it subservient to the human will is the proper empire of the human mind. Now that physics, physiology, and psychology will be compelled to unite their forces, and walk together the paths of scientific research, hand in hand, each step will be an advancing one toward that conquering of the material world which must precede the final reign of spirit over matter.

Ernest Renan has predicted that "a general upheaval and chaos" will follow the outbreak of anarchy and crime, now threatening to bar the progress of civilization on all sides and in all lands; that "human intelligence will be checkmated, thrown off the rails, so to speak, by events as yet

unparalleled." Great discoveries come when they are needed; never too early, never too late. With this hitherto unknown polar stream of exhaustless energy harnessed, as it now is, to machinery, we may expect an era of material prosperity to set in such as the world has never known.

The anchor of ancient faiths was in danger of being swept away by materialistic science, but the sheet-anchor of religious science has been let down from heaven, in our time of need; teaching us, as Wagner expressed it, that "the world lies in the bosom of God, like a child in its mother's arms," and with a mother's fond solicitude He administers to its wants as they arise.

When the underlying purposes of God are comprehended, the earth will be covered with the knowledge of God, as the waters cover the beds of the seas; and in that age of harmony, foretold in the Christian's Bible, the answer to the question "What is science?" will be, "Science is religion, as taught by Jesus Christ, the Son of God, who said to His disciples, 'the spirit of truth will guide you into all truth.'"

TOLSTOÏ'S "WHAT TO DO."

By Henry Wood.

Among all the multiform contributions to the great crucible of human thought there are perhaps none so unique, or even startling, as those of Count Lyof N. Tolstoï. Reformers and searchers for truth usually make their appearance in groups, or schools, in which various individuals, who are much in sympathy, endorse and supplement each other. Through a well-defined evolutionary process the time arrives when the world is ripe for some new development in science, art, sociology, or religion, and then it seems so to permeate the mental atmosphere that almost simultaneously it finds expression through many different channels. But there is only one Tolstoï. While he, like many others, holds for his ultimate ideal the attainment of human har-

mony and happiness, and the sweeping away of adverse conditions, yet his proposed *modus operandi* is so peculiar that both the man and his philosophy are sharply phenomenal. Of his earnestness, sincerity, and altruistic feeling there can be no question. His self renunciation, as shown in the voluntary and almost forcible abandonment of position, wealth, and social environment, is a standing object lesson of his whole-hearted devotion to the doctrines which he believes so essential to the reformation of human society. Any fair criticism of his opinions and methods must, therefore, be made in the light not only of his great talent and well-known benevolence, but also of the purity of his motives and intentions. He is willing to pay the full price for his eccentricity, though some claim that to certain natures there is a selfish charm in acute and persistent originality.

Preliminary to a brief examination of Tolstoï's social philosophy, as expounded and summed up in "What to Do," it is pertinent to consider the abnormal features of his early life, training, and environment. In his case it appears that subjective coloring has given a morbid hue to all objective social phenomena. In any true mental philosophy it is axiomatic that things without are rated, weighed, and interpreted through an inner personal bias, which often amounts to a decided idiosyncrasy. This may lead to utterly erroneous conclusions. If a score of people look out upon a landscape and pronounce it beautiful, and a single observer at the same time affirms it to be dull and gloomy, we conclude that the abnormal gloominess exists only in the individual. Intellectually he may be the superior of all the rest, but the feeling, or temperamental color, which is deeper than the intellect, gives a sombre shading to the whole picture. We, therefore, conclude that the impression gained is in a degree distorted. Not that normality is always lodged with the majority, but that a consensus of opinion usually involves a good degree of sanity.

The early life of Tolstoï, as shown in his "Childhood," "Boyhood," and "Youth," was, in his own estimation, peculiar, if not morbid. His early feelings of isolation, fits

of intense depression, peculiar friendships, abstract and unnatural intellectual processes, supposed philosophical discoveries, alternations of mental exaltation and depression, together with his university experiences, as given by himself, all indicate a mental combination far from symmetrical. A tendency to extremes and impractical conclusions regarding conduct and the philosophy of life, is, by his own testimony, everywhere evident. Without dwelling incidentally upon his early career, it is well understood that he indulged deeply in the pleasures, excesses, and extravagances which high rank and great wealth made easy in a country like Russia. At length all these things palled upon him and produced a condition of great restlessness. Then in earnest he began the study of his own nature, and human infelicity at large, and to devise some means of general improvement. His first efforts in social reform were made among the slums of Moscow. According to his own account, his plans proved an unmitigated failure. In speaking of the expectations which he held regarding the fruits of the organization which he formed among his wealthy associates to abolish misery, he says: "I already saw in the future begging and poverty entirely disappearing, I having been the means of its accomplishment." Experience, at length, taught him that mere material aid was no aid at all. After the utter failure of a series of well-meant efforts to elevate character through the distribution of money and food, he thus expresses his disappointment: "Unfortunately, I did not see this at the first, nor did I understand that such people needed to be relieved, not by my charity, but of their own false views of the world." He finally concluded, not only that city poverty and degradation are irredeemable, but also that cities themselves are an abomination, and that only through pastoral or country life is reform possible. Not only this, but that society must be reorganized, and revolution, peaceful or otherwise, inaugurated, before much improvement can be realized. He expresses no confidence in evolutionary progress.

Tolstoï's philosophy, as summed up in "What to Do," is not only positively materialistic, but deeply clouded with

pessimism. He sees little besides the dark side of life, and human existence is everywhere characterized as "a struggle with nature." The extreme contrasts of Russian social conditions are taken as typical of civilized life in other parts of Europe, and even of America. He has dwelt so long upon human evils and disorders, that they cover his whole mental horizon. He has a great and prolific mind, but all the more he gathers and stores up gloom without limit. Individual deficiency of character and immature development appear to him to be a studied and criminal injustice, for which society is to be held specifically responsible.

Humanity, according to Tolstoï, is composed of two classes; the rich, who have "freed themselves from labor," and the poor, who have not. The few who are favored by fortune are characterized as oppressors, who hold the larger part of mankind in bondage. Through the machinery of property and money they monopolize all products, and although serfdom has been technically abolished, the masses are still in servitude. In "What to Do" there is very little recognition of any possible progress through individual enterprise, industry, and excellence. Everything is fixed and fateful, because of some assumed iniquity in the external order of property, money, and wages.

That section of the human family who have "freed themselves from labor," are variously described, as living entirely for display; getting up at noon after nights of dissipation; indulging in unlimited champagne, cards, and sensuality; as being selfish, weak, and effeminate; as lording it over innumerable porters, cooks, footmen, coachmen and laundresses, who minister to their wants; and, in short, as a rule, to be the incarnation of greed, ostentation and (so-called) enjoyment. Any intelligent reader of "What to Do" will regard this outline of Tolstoï's lurid word painting as moderate and in no degree overdrawn.

That part of humanity who labor with muscle, Tolstoï looks upon as victims, sufferers, and slaves, who are forced to their unwilling tasks through the deceitful machinery of trade, custom, and the impositions of the State. They are

creatures of fate, destitute of independence, and their lot is one of intolerable hardship.

It is at once evident to the unbiased reader that Tolstoï is entirely mistaken in taking the extremes of Russian society to represent the civilization of Europe and especially of America. Any such premise is radically misleading. The vast majority are found in neither of these conditions, which only form the exceptions, or, more truly, the excrescences. One of the first requisites of any sound reasoning is to carefully discriminate between a thing *per se*, and its negatives and abuses. Tolstoï seems utterly oblivious to the great, subtle and universal law of compensation, which not only infallibly judges all systems and persons, but also inevitably enforces its penalties. He assumes that the luxury, and even vice, of the rich are enjoyable, and, by inference, teaches that they are a kind of benefit of which the poor are deprived. A deeper and truer philosophy shows that excesses of every kind invariably carry their punishment as an attachment, and that cause and effect cannot be severed, or even cheated by an iota. The fact that the poor have not the means to indulge in riotous living is therefore a blessing to them.

Tolstoï's definition of labor is virtually limited to that of physical exertion. The multiform varieties of mental labor he does not recognize. All such workers he puts into one great class who have "freed themselves from labor," and concludes that they are drones, or worse, in "the great struggle with nature" of which life is made up. He also ignores the fact that only a fraction of the whole aggregate of human effort is required to minister to the actual physical necessities of the race. It would be superfluous to prove in this connection that mental labor is truly labor, for every intelligent person knows that the average friction, wear and expenditure of energy connected with it are as great, and often more so, than that which accompanies simple manual effort. Still further, if man be anything more than an animal, it is evident that mental activity is as important as that which is physical. But it is inferred that the latter is a curse, and that if one does not definitely take part in it, from that very

reason he tyrannizes over his fellows. He ignores the fact that society is an organism, whose very unity, symmetry and completeness are necessarily made up of variety, and proposes that it be leveled down to a tedious and materialistic uniformity. Instead of diversity, specialty, and resulting perfect production, through which civilization has been evolved from barbarism, every man must occupy a large part of his time in the crudest and least fitting occupation. A vain attempt is thus made to repeal the universal and irrepealable natural law of adaptability.

Self-abnegation—a normal amount of which is good—is carried by Tolstoï to a disorderly extreme. The spirit of altruism, which consists in lifting men up, is stifled in the literal attempt to get down to their own level. Not that manual labor is less honorable or useful than mental exertion, but in the eternal order of things it is lower in evolutionary grade.

Society is not arbitrarily made up of two classes—unlucky workers and favored idlers—for, as work or activity is a universal law, all who in any measure evade it will receive penalty instead of benefit. Any man who does nothing for the world can as easily escape from his shadow while in the sunlight as to defy natural law by reaping what he has not sown. When, in future evolutionary progress, the plane of general unselfishness is reached, non-resistance will be practicable and external government superfluous, because then every man can and will be a law unto himself. But to force such a step in the outward letter, with the inward spirit and character immature and untamed, as they are at present, would make society resemble a menagerie, with every cage-door flung wide open. It is idle to galvanize goodness upon the outside of men, for it will not go even through the cuticle.

Man is more than body, and food and clothing comprise but a mere fraction of his needs and aspirations. The teacher or artist is as truly a producer as the farmer or boot-maker. The statement that "man shall not live by bread alone," is scientific in its accuracy. The ego is immaterial,

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and soul-hunger must be satisfied as man advances above the plane of mere animality.

Tolstoï characterizes taxation as slavery. Here, again, abuses are confused with that which is normal. In itself it is only a general and legitimate contribution for the public good. When levied to support great standing armies or luxurious courts, it is the distortion of a principle that is good in itself. Abuses are not a part of the social system, but are rather bare spots where there is a lack of it. The system may be normal, while the deficiencies are located in individuals who do not give it perfect expression.

Governments, property, and money are all characterized as bad; that is, bad in principle. He does not limit his criticism to their faults and shortcomings.

Regarding money, Tolstoï observes: "I saw that money in itself was not only not a good thing, but obviously an evil one," and then goes on at length in the attempt to prove and enforce the proposition. This is quite different from the Biblical teaching, which, though condemning the love of it—or its acquisition as an end—says nothing against it, of itself, or of its legitimate use. Again, he says (page 228), "Property is the root of all evil; and, at the same time, property is that towards which all the activity of our modern society is directed, and that which directs the activity of the world." This is a direct invitation to return to barbarism. If legitimate wealth, in itself, be an evil, then all its accessories and results must be similar in quality. The libraries, art museums, public gardens, parks, hospitals, asylums, charities, and numberless other institutions of any large city, are only made possible through accumulated wealth. They are all open to the poor and penniless, and are standing evidences of man's rapidly growing love for his fellows. Property *per se* is good. It represents stored-up labor, prudence, and industry. It is human accomplishment in preservation.

It is almost pathetic to see a great mind like Tolstoï's, eminent in sincerity, sympathy, and altruism, so darkened with pessimism and so entangled in literalism, that he is

able to discern no light, no hope, no improvement. He has gazed so long upon the negative side of the world that he can see no positive good, and life seems barren and joyless. For Tolstoï, and for the world in general, optimism would be salvation. Mental ideas are ever outwardly expressing themselves, and Shakspeare gave utterance to a profound philosophical principle when he said, "There is nothing, either good or bad, but thinking makes it so." With the best intentions, it is quite possible for one to subjectively dwell in abuses, deficiencies, and negations, until the entire objective realm becomes deranged and disheartening. Tolstoï's sombre beliefs and theories regarding human society and government are the logical result of subjective hopelessness. Theoretical anarchy is also the legitimate fruit of dwelling upon evil until color-blindness to the universal good and to evolutionary progress is complete.

The abnormality of Count Tolstoï's premises and conclusions in "What to Do" is so evident, that it seems quite superfluous to controvert them, when it can only be done by proving things which are already axiomatic. But the fact remains that there are thousands of illogical and superficial minds that are greatly influenced, and even thrown off their base, by doctrines plausibly put forth by one so noted and earnest as the great Russian nobleman. It is unfortunate that, through such teaching, restlessness and bitterness are increased, and that many sentimental and ignorant people have their envy and avarice inflamed and class antagonism stimulated. The "social system" is made the "scapegoat" for all individual crimes, mistakes and deficiencies. So long as any great adverse institution, outside, can be blamed for seeming misfortunes, there will be little attempt at individual reformation. Those penalties which come correctively to turn men from their personal errors, such as intemperance, improvidence, laziness and vice, have no more connection with the social framework than with the moon.

Tolstoï's great mistake, like that of many other impracticables, is in beginning at the circumference instead of the center. The universal, unchangeable order of causation is

from within outward, and all external institutions and governments are, therefore, only expressive and resultant. They are only the registers of the aggregate composite character which is back of them.

If it were possible for Tolstoï to artificially impose his ideas upon the world, the result would be the exact opposite of what he professedly seeks. Under such a *régime*, life would become drudgery, art wither, science expire, invention cease, and enterprise and industry die out. Barbarism would loom up in the immediate future, animalism become rampant, and evolution be turned back, until mankind would come down to the primeval level. But no one need despair. Any such movement is impossible, in the very nature of things. Evolutionary growth from within must go on, and no power can hold it back. In proportion as human character can be rectified, thinking elevated, natural law recognized, consciousness educated, and unselfishness realized, external systems, governments, money, and taxes will fall into line, for they are only the outward indexes of the human mind.

THE INFLUENCE OF HEAT AND COLD UPON MICROBES.

By Lawrence Irwell.

Although the magnifying property of the lens was known eighteen hundred years ago, yet the microscope was little more than a toy until the year 1757, when the introduction of the achromatic lens caused it to reach a high place as a scientific instrument. With the aid of modern inventions, the microscope has now enabled scientists to learn something of the habits of numerous low forms of life, whose very existence was in doubt until recent years. At the present day the expert microscopist can both see and measure objects no larger than the three-hundred-thousandth part of an inch.

In the following pages the words "microbe" and "micro-organism" are used synonymously to mean the lowest forms of life. The words "bacterium" and "bacillus" are often used somewhat indiscriminately with the same significance as the two former words; but as "bacterium" and "bacillus," strictly speaking, refer to a distinct genus of micro-organisms, it may be well to avoid the use of them in the general sense. The word "microbe" was originally introduced in 1878 to avoid any dispute as to the animal or vegetable nature of low organisms.

The extraordinary variations of temperature to which microbes can be subjected without the destruction of their vitality is almost beyond belief. So remarkable are the powers of endurance of these minute forms of life, that they caused one of the most serious controversies which science has experienced. I refer, of course, to the controversy concerning the theory of spontaneous generation, known to scientists as the theory of "abiogenesis," the point involved being, can life arise from dead matter *de novo*, and without the interposition of a parent? Of course, the microscope, with its wonderful revelations, soon destroyed the ideas of spontaneous generation in their ancient form, but a more scientific aspect

of the theory was afterward developed, and it certainly survived until a few years ago, and still exists, I suppose, in a moribund condition.

The microscope has shown the world of microbes to be a veritable wonderland indeed; it has shown them to appear so strangely and unexpectedly under certain conditions that the believers in abiogenesis will not credit their having proceeded from a parent, but profess to solve the problem by the simple assertion that these small forms of life have come into existence spontaneously.

It may be asked, how does this technical scientific question interest the public? The answer is, that it has now been satisfactorily proved that many diseases—typhoid fever and tuberculosis among the number—are caused by microbes, and it would be well that every thinking man and woman should clearly understand that these complaints cannot arise spontaneously, but appear to be always produced by the action of some already existing germs.

I must distinctly state that the following pages make no claim to originality, and that this entire article consists merely of a summary of the experiments which have proved the truth of the theory of biogenesis, by which is meant the doctrine that the production of living organisms can take place only through the agency of a living parent or parents.

More than a hundred years ago it was confidently asserted that animalcules were spontaneously generated from more highly organized bodies in a state of putrefaction. Ever since this theory has been periodically exhumed, and bolstered up by new arguments, only to be refuted again and again by carefully collected experimental evidence.

The most scientific upholder of the theory of spontaneous generation was—I am unable to say whether he has changed his views—Dr. Henry Charlton Bastian, the author of "Modes of Origin of Lowest Organisms," and also of "The Beginnings of Life." This gentleman reasoned that, as nobody denies that boiling water kills all forms of life, it therefore follows that if living forms appear in fluids which have been boiled in flasks, afterward hermetically sealed,

they must have arisen from inorganic matter—investigations show that they do so appear, therefore spontaneous generation is a verity. Other observers repeated Dr. Bastian's experiments, and found them to be substantially correct, and were then either forced to his belief, or were bound to show that his premise—that boiling water destroys all forms of life—is incorrect. But, in justice to Dr, Bastian, it should be mentioned that twenty years since he admitted that the boiling *for four hours* of the seed of medicago, of which "snail-clover" is one variety, failed to injure its reproductive power.

For the elucidation of this subject, we are very largely indebted to the labors of the late Professor John Tyndall, who proved that a temperature of 212° Fahrenheit cannot be relied upon to kill every form of living organism. To this fact the upholders of the theory of spontaneous generation paid little attention; they simply reiterated their assertion: "In a few hours myriads of animalcules appear in a few drops of putrescent fluid. As they cannot have arisen in the ordinary course of nature, they must have developed spontaneously from the particles of decaying animal matter." This sounds very plausible, especially to persons who are ignorant of logic; and if we look only at the laws of propagation among the higher animals it might seem a valuable argument. But, as soon as we have examined the life history of the lowest forms of life, we need no longer wonder at their sudden appearance, their survival under extraordinary conditions, or their universal dissemination.

If a piece of hay be steeped in water, and examined with the microscope after a few hours, countless swarms of microbes are seen. Where do they come from, was the question asked? This was answered by Mr. Kent, who detected upon newly-moistened hay coatings of extremely minute capsules, or spores, one-twenty-thousandth part of an inch in size, which were seen to increase and ultimately to develop into microbes. Mr. Dallinger went a step further; he showed that these spores were the product, not of the decomposition

of the hay, but of living progenitors. With a wonderful amount of patience, he watched one particular adult animalcule in all its wanderings, until it grew quiescent, encasing itself, and at last breaking up its entire body into minute particles or spores. These spores being distributed into the surrounding fluid, were observed eventually to reach a condition identical with that of the deceased parent.

Mr. Kent showed that the liquid squeezed from dew-laden grass, when inspected under the microscope, swarmed with minute forms of life in an active condition. Where did they come from? Yesterday they were absent, for the grass was dry; and it is only in moisture that the adult microbes of most species display activity. Whenever the heat of the sun dries the grass, some of them become encysted, and their animation is suspended until the rain, or the dew, causes them to renew their activity. But it is to the spores—which, owing to the extraordinary fertility and rapid maturity of micro-organisms, are always being produced where the adults are—we must look for the perpetuation of the species after periods of prolonged drought. These spores, like the seeds of plants, resist the dry weather and cling to the grass, thus showing us how it is possible for enormous numbers of micro-organisms to be obtained from infusions of hay.

Hay is not, of course, the only residence of microbes, nor is it by any means the only resting place of the spores; the air is full of them, being well supplied, by means of the wind, from withered vegetation and dried-up swamps; these spores being ready to settle in any damp place and develop into full activity. This explains how a fluid—or any wet substance—set aside after being thoroughly boiled, but not protected from the atmosphere, may quickly show signs of life. To this statement the believers in spontaneous generation answer that nobody has seen the germs in the atmosphere—a reply about on a level with that of the man who insisted that we could not know the distance from the earth to the moon because nobody had taken the trip! Mr. Dallinger's refutation of that argument was the following experiment (M. Pasteur and Professor Tyndall also worked along the

same line): The first-named scientist took a fluid full of a particular species of germs, and, after evaporating it to dryness, collected the remaining dust. He then scattered this dust in a specially prepared vessel, and putting in a "sterilized" fluid, found, when the dust settled into it, that only the species which was contained in the original liquid developed, thus showing that the vitality of the spores was not destroyed while they were in a dry condition, and that moisture enabled them to recommence their active life. Repeating the process with more of the sterilized fluid, but with the sporidial dust of other species, these particular species invariably appeared. Further, it was found that the portions of the liquid put in first, where no dust of more than one species was used at the same time, gave rise chiefly to the species having large spores; the liquid poured in later, chiefly to the species having smaller spores; and finally that none at all were produced—this evidence showing that the larger settled first; that the smaller ones took a longer time to do so; and that there came a time when all had subsided. It is obvious that extreme care had to be taken not to shake anything, lest any of the dust should be again stirred into the air in the vessel. These results were much too regular for spontaneous generation, which should either have given the same species upon every occasion, or a heterogeneous mixture of microbes each time.

I have mentioned a "sterilized" fluid, meaning one rendered free of all vital spores. The late Professor Tyndall has shown how such a fluid can be prepared, although many spores resist subjection to the simple act of boiling. The process is as follows: Boil the water for a short time, that kills the majority of the adult germs; then place the vessel containing the liquid in a warm temperature for twelve hours, when a large number of the spores will have approached development. Boil the water again, and these will be killed. When this process has been repeated about half a dozen times, the last spore will have matured sufficiently to be killed by boiling, and no spore during the intervals of boiling will have advanced enough to reach the reproductive

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stage. How long spores can retain their vitality in a dried condition is not known, but they undoubtedly can do so for years. Adult microbes are very frequently destroyed by the simple process of boiling; and while that process may render the bacilli of typhoid fever innocuous, it will not prevent the growth of the spores in the water, nor will it remove the poisonous alkaloids already generated by the bacilli. Whenever water of doubtful purity is intended for drinking purposes, it should be boiled for not less than half an hour. If that be done, a moderate degree of protection against typhoid fever will be insured. Absolute safety can only be obtained by boiling the water for at least two hours, and by filtration afterward through some scientifically-made filter. I doubt whether the latter precautions are practicable in most private residences.

The question of the power of resistance of microbes to cold now presents itself.

Dr. McKendrick, of Glasgow, Scotland, wanted to ascertain whether prolonged exposure to cold of putrescible substances in a hermetically sealed bottle would cause death to the microbes. Putrefactive fermentation only takes place in the presence of germs, and as the atmosphere is full of them, the liability of certain substances to putrefaction need cause no surprise. It is well-known that many kinds of food, meat for instance, can be kept from putrefying by the process of freezing. Does this destroy the germs of decomposition, or does it merely cause them to lose their vitality so long as they are in the frozen state? Dr. McKendrick employed a Bell-Coleman machine, such as is used on ships for keeping carcasses in a frozen condition. By this means he was able, not only to get the lowest temperature yet reached for such purposes, but also to maintain that degree of coldness for an unlimited period. He placed some meat in bottles, hermetically sealed them, and then exposed them to a temperature of —20° F. for one hundred consecutive hours; he then placed the bottles, still sealed, in a warm room, and found, after twelve hours, that the putrefactive process was in progress, a conclusive proof that the germs of putrefaction

were only dormant while the meat was frozen. To show more directly the effect of extreme cold upon the microbes, putrefying fluids full of them were exposed to —120° for a hundred consecutive hours. The thawed fluid was examined under the microscope, and the organisms were found to be motionless. When examined again, after the liquid had stood in a warm temperature, it was found to be swarming with microbes in a vigorous state of activity.

As experiments had shown that repeated boilings sterilized a fluid, it was considered possible that continued freezing and thawing might have the same result. But this is not the case; it is not possible to destroy the various crops of spores by any amount of freezing, consequently the greatest caution should be observed in the use of natural ice for cooling food, or drinking water; it is not safe to allow such ice to come into contact with anything that is to be eaten or drunk. As artificially manufactured ice, made from distilled water, is not always procurable, natural ice should only be used *outside* the pitcher containing the drinking water, and should under no circumstances touch the food. The only exception to this rule is when conclusive proof exists that the body of water from which the ice is taken is not contaminated by sewage.

The whole of this evidence, then, goes to show that the spores of micro-organisms preserve their vitality from —120° F. up to 300° F., the former temperature being far below anything experienced in the Arctic regions; and also that they may be dried up and quite inactive for years, and yet resume their vitality under favorable conditions.

Although the specific germs of small-pox, cholera, and many other diseases are not yet positively known, very little doubt exists that these maladies are caused by living organisms. While it is unquestionably true that when the human system is in a strong condition it will resist the attacks of microbes, yet too much care in obtaining fresh and clean food, as well as pure milk and water, cannot be taken.

The proper use of germicides and antiseptics is not understood by the public, which regards "disinfection" as the

substitution of the nasty smell of the drug for the previously existing stench. If an inodorous so-called "disinfectant" were employed, not even the imagination would be satisfied, and the plan of living in a fool's paradise—the supposed safety resulting from saturating the air of a room, or a whole house, with the smell of chemicals—would die a natural death. The only sensible method is to ascertain the cause of the offensive odor, and to get rid of that cause. The use of "microbe-killers" and germicides should be avoided, unless advised by a properly qualified person. Carbolic acid is not another name for magic, and its effect is often inferior to that of hot water; under no circumstances can it take the place of that liquid.

A REMARKABLE BOOK, AND ITS TEACHINGS.[1]

By Wentworth Lascelles-Scott.

"The very nerves and sinews of knowledge consist in believing nothing rashly." Epicharmus.

Although the sentence quoted above was written long prior to the commencement of the Christian Era, its intrinsic truth remains even now in force and pertinency undiminished, and, in latter-day diction, unsurpassed. By all inquirers into that department of Nature's cosmical phenomena which, not too happily, we call "physics," it may be taken as a safe-guarding text upon which more than one long sermon of absorbing interest could well be founded; and, moreover, it is a text which has always commended itself to the writer as being of especial value and importance. When, therefore, he was invited by the editor of this magazine to review for its pages the work which forms the subject of the present article, the words of the old Sicilian philosopher appeared to be especially appropriate. But there are a good many people nowadays who seem to act upon the Epicharmian dogma, *minus* the last word, the moment that any proposition

[1] *Keely, and His Discoveries.* By Mrs. Bloomfield Moore. London: Kegan, Paul, Trench, Trubner & Co., Limited, Paternoster House, Charing Cross Road.

is laid before them which does not fit in well with their own preconceived—and not infrequently extremely narrow—views, or appears to be more or less at variance with the "laws" cited in the orthodox text-books of the period.

However, between the Scylla of bigoted disbelief, and the Charybdis of fatuous, unreasoning credulity, there is a middle, and a more rational course; it is the latter which should be that of an impartial reviewer, and it is that along which the present writer proposes to steer. In this way, whilst "believing nothing *rashly*," it may be possible to give due consideration to fresh results, or to novel theories, and thus to make some—if only infinitesimal—progress toward the elucidation of some of the physical mysteries of Nature.

Mrs. Bloomfield Moore's "Keely, and His Discoveries" is, in more senses than one, a most remarkable book, and those who peruse it intelligently and dispassionately, can scarcely fail to appreciate the enormous, not to say revolutionary, influence these discoveries must necessarily exert upon physical science both theoretical and applied, if but a fraction of the propositions therein shadowed forth be (a) reduced to comprehensible language and (b) industrially applied.

Keely, like most other inventive physicists, appears to have started his serious researches with the notion of making an engine, or mechanical motor, of such power as to completely eclipse anything and everything of its class previously constructed. In other words, it should do more "work"—*i. e.*, raise more "foot-pounds" in a unit of time—than had hitherto been accomplished with an equal weight of metal and similar expenditure of fuel or its equivalent. According to the authoress:

"He made the mistake of pursuing his researches of *invention* instead of *discovery*. All his thoughts were concentrated in this direction up to the year 1882. Engine after engine was abandoned and sold as old metal, in his repeated failures to construct one that would keep up the motion of the ether that is necessary to hold it in any structure. Explosion after explosion occurred; sometimes harmless to him, at other times laying him up for weeks at a time."

This state of affairs, which by 1882 had extended over more than a decade, seems to have lasted several years longer, until, partly upon his own initiative, partly at the instigation of another, Keely appears to have exchanged, in a measure, the rôle of an inventive mechanic for that of a theoretical physicist. In other words, he then, in some measure, abandoned the work-shop of the motor-engineer in favor of the—if not more exalted, at least more academic—regions of the laboratory and the study. During the former period, however, which may be said to have terminated with the year 1888, there can be no reasonable doubt that Keely "discovered," either quite accidentally or by a process of inductive evolution, a force, or the resultant of two or more forces, capable of performing "work," or manifesting potential energy, which is not subject to the laws (as we at present consider them) governing either gravity, magnetism, or electricity, but yet a force of which the value, if it could be adequately expressed in foot-pounds, would be found immensely superior to that of any hitherto known.

Having got—or believing that he had got—thus far, at the outset, it was a very natural impulse which apparently actuated the discoverer, long before he had any idea of the condition under which this force was generated or transmitted, in endeavoring to confine, regulate, and generally control it through the instrumentality of a machine or "motor."

The salient features in the history of the "Keely motor," and the syndicate or company by whom it was to be prospected for the benefit of the promoters (chiefly) and the entire mechanical world, are well, and on the whole fairly, described in Mrs. Moore's book. The authoress knows full well that her hero has faults, and she neither conceals nor attempts to palliate them, as a more bigoted or less intelligent partisan would have done; the entire fabric is unrolled and opened out before us, and with almost supererogatory honesty our particular attention is directed to the spots. Nevertheless, the summary of the evidence adduced sufficiently shows that Keely himself cannot be held responsible for the errors and the sharp practice of certain directors and

promoters, which he neither authorized nor benefited by. In proof of the foregoing, the judgment of the Supreme Court (New York, 1888) in favor of the inventor, as quoted verbatim at pages 111 and 112, should be amply sufficient for any evenly-balanced mind.

It is unnecessary in the present article to follow the fortunes of the Motor Company. The name was casually mentioned to the writer several years ago in such unflattering terms that he took no interest whatever in the matter, and the very name of "Keely" passed completely out of mind until not quite three months ago. In the *Nineteenth Century* for June of this year, an article appeared entitled "Modern Explosives," which appears to have attracted an unusual degree of attention both in England and elsewhere. Herein was shown for the first time the noteworthy fact that:

"When an intense explosive is approaching its critical state, and its molecules, therefore, are in a condition of *very unstable* equilibrium, the sudden emission of a musical note will frequently bring matters to a climax and induce detonation."[1] Illustrative examples having been adduced, an explanation of the phenomenon is suggested in the following terms:

"On the assumption that (in common with all other substances) (a) the molecules of explosives were always in a condition of either linear vibration or spiral swing; (b) that the velocity of such oscillations was constant with such substance according to its composition; (c) that the amplitude or wave-length thereof varied with the temperature; it might not be unreasonable to suppose, as the oscillations extended until they approached the point of disruption, that the impact of sound vibrations bearing some simple numerical relation to their own, might carry those molecules too far, and thus precipitate their severance."[2]

Elsewhere in the same article occur these words:

[1] "Modern Explosives," by W. Lascelles-Scott. *The Nineteenth Century.* Vol. XXXV., page 997.

[2] "Modern Explosives," by W. Lascelles-Scott. *The Nineteenth Century.* Vol. XXXV., page 997.

"It is just this property of *explosion by sympathy*, if the expression is permissible, which renders these substances so valuable—and dangerous."[1]

The writer had long believed that—not necessarily *synchronous*, as some rather superficial critics have erroneously imagined, but—*sympathetic* vibrations exerted no insignificant influence in the economy of nature, as evidenced, to his thinking, in (1) the starting and subsequent hastening of crystallization by the incidence of certain well-defined musical notes; (2) the earlier bursting of the anthers of flowers under similar sound influences; (3) the effect of luminous vibrations upon chemical combination, and, more rarely, upon chemical dissociation, and in various other ways.

In this connection it might even be pertinent to inquire whether the seemingly purposeless waste of time often incurred by bees and other insects in hovering just over a flower whose anthers are barely "ripe," their wings emitting a steady "hum" the while for some time before alighting thereon, may not in reality be "instinct with purpose of the great design." It has appeared to the writer—who had intended to ask Sir John Lubbock whether he had any experiences tending to confirm or negative this hypothesis, but omitted to do so in time for press—in the great majority of instances watched by him, that the anthers burst shortly after being subject to the vibration of that "hum;" and it was subsequently found that—in the case of lilies, at all events—the fructification of flowers could be visibly facilitated by prolonging and sustaining the "note" of the bees' hum upon a concertina in the immediate vicinity of the blossom.

Hence, when invited on behalf of the editor of this magazine to contribute for the October number an impartial review of "Keely, and His Discoveries," from the standpoint of an English scientist, the writer, up to that time knowing nothing whatever of either the book or the man, was naturally startled by certain strongly marked coincidences.

[1] "Modern Explosives," by W. Lascelles-Scott. *The Nineteenth Century*, Vol. XXXV., page 995.

"Sympathetic vibration" is, as the Wagnerites might say, the *leit-motif* running through the volume, and presumably also the very foundation-stone upon which the entire structure of Keely's researches and facts—if they *are* facts; or chimeras, if they *are* chimeras—is based. That is to say, that upon the assumption, or in the belief, that all substances —whether according to the present knowledge they be classed as simple, elementary bodies, or as compounds—consist of molecules, which are in a state of chronic vibration or oscillation; the vibrations occur at such regular intervals that they are capable, acoustically, or graphically, of being represented by a particular physical note or combination of notes. Moreover, if the identical note peculiar to a certain substance be sounded by appropriate means in the immediate vicinity of that substance, the particles or molecules of the latter (in principle, although not necessarily by way of emitting an audible sound) will "respond" precisely as a harp-string or an organ-pipe tuned to the same note will do under similar conditions.

Now, musicians and physicists have long been agreed upon the subject of sympathetic vibration, so far as the universally admitted fact that any solid body capable of emitting a sound, when excited to vibration (and, for that matter, so far as we know, most fluids as well), may be induced to "speak" the "note" peculiar to its composition, dimensions, and conformation, in at least two ways; *viz.*, (a) by being sharply struck with a suitable beater, and (b) by being exposed to the influence of the same note's vibrations sounded in its vicinity. In addition to solids, atmospheric air and other gases can also be musically actuated, if confined by containing vessels of size and shape appropriate to the note determined upon.

Within certain limits the result of the emission of musical vibrations, or "notes," in this manner tends only to the enhancement of the original sound by the resonating or responding one, a fact constantly taken advantage of in the construction of musical instruments. But if the operation be continued under certain conditions, in such manner that

the vibrations of the resonator are progressively excited to greater amplitude, it is quite possible that they may extend too far for the cohesion of the "responding" body; in such, the resonator itself falls to pieces.

The old story about the iron bridge at Coalbrookdale illustrates the foregoing very well. When this bridge was in course of construction, an itinerant musician, who had been refused alms by the workmen, threatened to "fiddle their bridge down" unless they gave him money. At first the men only laughed; but in less than a quarter of an hour the player had found the particular note with which the bridge was harmonically in sympathy, and by persistently "fiddling" upon that note, the bridge at length began to oscillate so violently that the foreman was alarmed, and quickly came to terms with the performer. On the same principle, an esteemed friend of the writer[1] gifted with a powerfully resonant voice succeeded, at his instigation, on one occasion, in breaking a large glass tankard, simply by singing its own "response-note," which happened to be as nearly as possible the bass Db.

But subsequently it was found that musical vibrations were not only capable "sympathetically" of causing the physical disintegration of various articles, but would influence the chemical dissociation of certain compounds, as already noted with regard to "intense" explosives. Experiments of this class are frequently complicated by the incidence of various disturbing causes, but the main features, as published in the *Nineteenth Century* before quoted, are indubitable. Hence, when Keely speaks of "sympathetic vibration" as a virile influence of considerable importance, it is futile to insinuate a doubt, or venture upon a sneer, since thus far he has been confirmed or anticipated by independent observers, having at the time no knowledge of his theories, or of the man himself. In other words, after that comprehensive proposition upon which the book under

[1] Ercolé Caflisch, Esq., of Wolverhampton, Staffordshire; formerly of Zurich, Switzerland.

consideration is evidently chiefly based, may fairly be written the Euclidian formula: Q. E. D.

It is in passing onward that the reader finds himself in difficulties of no ordinary or superficial kind. Keely—whatever may be thought of his conclusions, distinctions, and assertions, *per se*—has certainly carried his researches upon the sympathetic vibration principle very much further than any one else has yet done, in public at all events; and it is here that some unlucky individualities of his own vitiate in a greater or lesser degree all his so-called explanations, and much of his actual work. The authoress, or, as with excessive modesty she styles herself, the "compiler" of the book, by this time probably seriously regrets that she has permitted "Keely, and His Discoveries" to run through quite so many chapters, and also that the physicist's own language is so frequently and at such length quoted therein. For it must be candidly admitted that this latter portion of the text is so hopelessly entangled in a wild jargon of wrongly-applied technical terms, that it appears a very abracadabra of unreason rather than the scientific notes and theories of a nineteenth century experimentalist.

Novel hypotheses, instruments, and appliances not infrequently require to be expressed in, and designated by, terms peculiar to themselves, and coined distinctively; but the result of using such new words should be to facilitate comprehension, not to render it impossible. Yet in the Keely *patois* we have perfectly familiar chemical, physical, musical, and other technical terms so wrongly applied, and so confusedly mixed up, that the most painstaking reviewer speedily finds himself in the midst of a verbose conglomerate of words, which afford no clue whatever to their intended meaning.

When, however, we get rid of Keelyese and substitute the authoress's own language—even handicapped as it is by the terms supplied to her—a little light is thrown upon the Cimmerian obscurity of the physicist's diction, and it is possible—if we take the trouble—to evolve something like a rational notion of what Keely is doing, or what he has already accomplished.

In the first place, whilst neither "holding a brief" for or against the physicist and his ablest exponent, the authoress of the volume now under review, the writer has not hesitated to ask himself whether the whole thing is an imposture (devised with the idea of inducing people to subscribe for, or invest in, some *Chateau d'Espagne* limited), or is otherwise an egregious congeries of blunders from beginning to end. Were there nothing more to go upon than the inventor's inscrutable vagaries of diction, the present article would, if written at all, have dealt with the matter in a very different spirit, and one or other of the preceding queries must have been replied to in the affirmative. The results of over two months' study, however, have fairly convinced the writer (despite numerous errors of detail, and a few of some magnitude), that there is a good deal of method in the apparent madness of Keely's physical researches; and, further, that Mrs. Moore has written a book the teachings of which will prove far more important in the twentieth century than perhaps can be the case in this one.

"The sympathetic" influences of *sound* vibrations or musical "notes" have already been slightly adverted to; but it must be remembered that the vibration limits of *audible* notes are comparatively narrow. Helmholtz, the distinguished physicist, who has passed from our midst while these lines were in course of transcription, considered that the "note" produced by twenty-three vibrations per second[1] is the lowest audible one, and that all "sounds" produced by more than thirty-eight thousand vibrations per second are absolutely inaudible. Latterly, however,[2] he gives sixteen as the limit for low sounds. The range of musical perception, however, varies greatly with individuals, and some persons only hear the highest and the lowest octaves of a

[1] The range of an Erard seven-octave concert-grand pianoforte C. to C. is from thirty-three to four thousand two hundred and twenty-four vibrations per second, or from twenty-seven and one-half vibrations for the seven and one-quarter octaves instruments.

[2] Helmholtz. *Tonempfindungen*, p. 30.

piano as so many knocks instead of notes.[1] The late Professor Tyndall was once kind enough to test the writer's sensitiveness in this respect, when it was found possible to hear musical "notes" having as few as fourteen and as many as forty-two thousand vibrations per second. Nevertheless, sound does not cease merely because human *tympani* are not excitable by vibrations of much over forty thousand per second. By means of his ingeniously constructed whistles, it was demonstrated by Galton, sixteen or seventeen years ago, that some animals, and notably birds and cats, could hear "notes" so shrill—*i. e.*, caused by such a high rate of vibration—that the human ear could not distinguish them from absolute silence. Yet one of these "inaudible whistles," the writer found, sometimes sufficed to partly overcome the cohesion of a slender rod of quickly cooled resin. When, therefore, we are told—as the authoress, in other words, tells us more than once—that if masses of certain substances be molecularly hyperexcited to sympathetic vibration by sound waves, they will be more or less disintegrated, and may even rapidly fall to pieces, it is impossible to meet the assertion with either honest denial or careless ridicule. In this, at least, Keely appears—however great the ultimate mechanical results may prove to be—to have simply developed and immensely extended the manifestation of a principle previously known.

Let the reader of average intelligence once admit this much—for, practically, he can scarcely help himself, since it is irrefragable—and both scientifically and logically he must go still further.

The veriest tyro in physical technology will have gathered from the foregoing that no limit whatever can be assigned to the number of sound-vibrations per second of time which are possible, whether the resultant musical "note" be audible to any ear, human or feline, or not. But when such vibrations—too numerous in a given time, and therefore too "finely

[1] To such people the "intense" shrill notes emitted by the grasshopper and various other insects are absolutely inaudible.

divided" to affect animal tympani—with ever heightening "pitch," pass on from a few thousand to many, through several phases of what might be termed *ultra-musical silence,* to a greatly enhanced rate, they again become appreciable by the animal senses, although we no longer speak of their effect as "music," or "sound." It is now called "heat." Lastly, if the resilient speed of "heat" vibrations be further accelerated until they amount to some hundreds of *billions* per second,[1] they are then capable of appreciation by the retina and the optic nerve, and we apply to such vibrations the term "light." Surpassingly rapid as these vibrations undoubtedly are, there is no reason for supposing that at eight hundred or one thousand billions per second, their final limit has been reached. On the contrary, it is quite within the boundaries of rational hypothesis that light-vibrations accelerated to a yet higher "pitch" (to borrow a convenient musical term, for the nonce) are in their turn "translated" into something—neither sound, heat, nor light—for which we have yet to coin an appropriate name. By way of evidencing the commencement of these ultra-luminous vibrations we may point to those "dark" actinic rays beyond the violet end of the spectrum, which are such potent factors in the dissociation of chemical molecules, as familiarly demonstrated in photography, but which remain invisible to human eyes until we (still speaking in music language) transpose them to a lower "key" by the aid of some so-called fluorescent substance. *Then* the "dark" rays become "light" rays and we can "see" them.

Thus far we have been treading upon fairly solid ground, although along a steeply ascending pathway; but can it be possible that Mr. Keely has gone beyond and above this secure resting-place of our cosmical journey, and that the ultra-sound, ultra-heat, ultra-light, ultra-actinic "rays" just hinted at in the preceding paragraph, whose vibrations must number thousands—or tens of thousands—of billions per second,

[1] According to Sir John Herschell the light vibrations of the solar spectrum vary from 458,000,000,000,000 per second for the extreme red, to 727,000,000,000,000 for the extreme violet rays.

will supply us with that potent "triune polar stream" or "etheric force" regarding which its discoverer is so sanguine?

If any dispassionate student will attentively peruse, first, the present article, and then—sternly putting on one side much of the labored, inflated, and needlessly nebulous diction of the "Keelyese" portion of the text—Mrs. Moore's interesting and important book, his reply to the above question will be: "Well, it really looks rather like it, after all!"

It may here be as well to observe that the writer is well aware that it is quite usual to draw a hard and fast line of demarcation between sound vibrations, on the one hand, and those of heat and light upon the other, by assuming that in the former case the undulations are longitudinal, and in the latter, transverse. But this clumsy and unnecessary distinction in no way commends itself to the writer, who, therefore (for divers reasons, impossible to enter upon here), prefers to consider them as being similar both as to configuration and direction. Again, whilst sound is very generally thought to be only transmissible by material and ponderable media, this hypothesis is supported neither by direct evidence, nor by inductive reasoning of a conclusive kind. Doubtless, in order to account for the wave-progression of radiant light, heat, and magnetism, it was necessary to prognose the existence of an apolaric, interstitial "ether" (in support of which theory material evidence is constantly accumulating); but, just because "notes" of low "pitch" cannot be heard through an air-vacuum, it is no more reasonable to say that *no* sound-waves whatever are transmissible through the "ether," than it would be to assume that windows are useless because we cannot induce a beam of monochromatic green light to pass through a sheet of ruby glass!

Hence, in these pages, it has been deemed expedient to deal with these several "impulse-forces" upon a common basis, as manifested or conveyed by series of vibrations of like character, but of progressive intensity. The writer had an opportunity of asking Professor Tyndall—about a year and a half before his lamented death—whether this view

commended itself to him or not, and his reply was to the following effect:

"I was not always of that opinion, but now I am disposed to think your views correct; so that with a few vibrations per second sound is generated; when more numerous, you may, as you suppose, get light, heat, and electricity; again multiplying them by the squares of millions, and who can say what might, or might not be the result? *Possibly, energy enough to divert the planets from their orbits!* But, then, where are those untold myriads of vibrations to be derived from?"

That, with the present writer, has remained one of the insoluble questions of years long past. Can Keely, or his best exponent, the authoress of the book now before us, answer it in any degree? So far as—what the inventor himself might probably designate—an unregenerate outsider can judge (from the broad intention and general context of the treatise rather than from any comprehensible working details), it is claimed that the Philadelphia physicist has discovered (amongst other things) a means of overcoming the cohesion of various substances—quartzose rock, for example—without having recourse to the ordinary mechanical operations of crushing or grinding. Also, that this is accomplished by first ascertaining what is infelicitously called the substance's "chord of mass," and subsequently sounding that particular "chord" or "note"—for these words are used indiscriminately, and, in Keelyese, seemingly mean the same thing—when the quartz, perforce, sympathetically responding to its "key-note"[1] (or some overtones thereof) rapidly breaks up into pieces or fine powder. As to this experiment, the authoress herself bears witness to the fact; she has seen

[1] Helmholtz has shown (and all musicians are aware of the fact) that when a note is sounded, say, upon the piano, not only is that special note emitted, but the string also gives forth more faintly a series of higher notes whose vibrations are not many multiples of the original note. Thus, if the Treble C, of 528 per second be struck, the sound we hear is not C pure and simple, but a mixture thereof, with certain "overtones" or "partials."

C.	C.′	G.′	C.″	E.″	G.″	Bb.″	
528.	1056.	1584.	1112.	1640.	2168.	2696.	and so on.

hard gold quartz reduced in this manner to an impalpable powder, which was carried away by the effluent water.

Such a process, if really available for the treatment of quantities of ore, etc., should be capable of very extended applications in the industrial arts. But it is also claimed for this method, or a modification thereof, that it will even *chemically* dissociate various bodies, such as water, for instance, resolving them into their constituent elements, and beyond. We are now carried completely past anything and everything that has hitherto been accomplished, and the decomposition of hydrogen is referred to by the authoress in the calm, almost commonplace, manner of one who speaks from the assured ground of actual knowledge, as an eye-witness.

It is here that the writer, in his capacity of chemist, is perhaps inclined to join issue with both the experimenter and the authoress, since statements of this nature should not be made except upon evidence of the most conclusive character, and which moreover can be demonstrated, when challenged, in such a manner as to leave no possible loophole for doubt to creep in. Mrs. Moore, who may be looked upon as editor of the text-book of "sympathetic vibrations," might well have applied the "blue pencil" at this point, unless empowered to afford such details of method that any skilled scientist with her book in his hand, and the necessary appliances, could dissociate or split up pure hydrogen into its ultimate components for himself. In addition to the foregoing, it must be said that amongst the various "unsatisfied requirements" of a question of this magnitude, we are told of the accomplished dissociation of hydrogen, but of that very essential corollary—the nature and properties of its constituents—we have no hint whatever.

Hence, in the writer's opinion, either too little or too much has been said, and, although not improbably the whole of our so-called elements are decomposible, the alleged compound nature of any one of them—hydrogen included—must, upon the evidence adduced so far, be met with the Scotch verdict: "Not proven."

XUM

A pregnant example of the necessity for caution in dealing with questions of this kind was afforded at the meeting of the British Association[1] this year, when a "new gas" was said to have been obtained by the electrolyzation of nitrogen; nothing transpired, however, to show that the authors of the paper had accomplished much more than had been done long ago by Cavendish.

Nevertheless it would certainly appear that Keely in the course of his "disintegration" and "dissociation" experiments has, or believes he has, discovered a new force, being neither electricity, magnetism, gravity, nor any of the other sources of energy with which we are acquainted, but considerably more powerful than either, taking into consideration the comparatively small size of the appliances needed for its collection and distribution.

Here, again, the actual *modus operandi* and the theoretical conditions involved are so nebulously entangled in a dictional whirlpool of Bohemian technology that any quoted explanation would only serve to confuse the reader in place of enlightening him.

For instance, the term "enharmonic" is employed by physicists and musicians in reference to very *small* intervals on the diatonic scale, and is in such relationship generally understood. Keely applies the word to one of the three kinds of vibration he attributes as normal to the molecules of all matter, so that the usual significance of the word is entirely lost and its newer specific meaning is not explained. Similarly the sense intended to be conveyed by "harmonic," "dominant," "negative attraction," etc., etc., cannot be gauged by the perceptive faculties of the ordinary reviewer, their accepted significations being quite impossible.

Hence, we must content ourselves with the merest outline of the idea as after prolonged study it presents itself to the reader—whether such a version be correct from the inventor's standpoint or not.

Roughly, it will be gathered, that in the decomposition

[1] Vide: "A New Gas," by Lord Rayleigh.

of water by what, for brevity's sake, may perhaps be termed *vibroid analysis*,[1] a certain stage in the process is stated to be marked by a sudden and immense increase of pressure. This pressure was not to be accounted for by the expansion into vapor, or its constituent gases, of the few drops of water under operation, and, more recently, the phenomenon was considered to be a development of a hitherto latent unknown force constantly present as a constituent of every substance known, and especially of that subtle, imponderable fluid, the "ether," which pervades all space, and impregnates the molecular interstices of all matter.

This "ether," the chief medium of transmission for heat, magnetism, etc., and the sole channel in which light can travel, hitherto unconfinable by glass or metal walls, however dense and compact, was found, according to Keely, safely imprisoned during these "dissociation" experiments, so long as a high rate of vibration was kept up. It there proved to be the medium of one current of the so-called "triune polar flow," which Mrs. Moore, evidently speaking "by the card," designates as "Nature's most powerful agent."

In this connection it is interesting to note that a few years ago, Hertz—another of the work-thinkers of science untimely lost to us—said that "ether" was held fast bound in all electro-magnetic engines.

Keely considers that this force, if we are reading the story aright, is present in all magnets (including, of course, our great magnet, the earth), and is that which acts as "fender" to those forces of the opposite poles. Anyhow, it is claimed that the long researches are now complete, and only wait practical applications in the work-shops of the world. Objections to the statement that gravitation can now be neutralized, do not, in the writer's opinion, appear intrinsically valid, since we know, or ought to know, that this is not impossible, by any means. A simple wire spiral along which a strong voltaic current is passed—a "solenoid" in fact—will keep an iron knitting-needle in the direction of its axis

[1] For this term the writer alone is responsible.

suspended in mid-air, despite gravitation, for any desired time; and if a hollow sphere of xylonite be "excited" interiorly, a pith ball may be "hung up centrally" in similar fashion.

Hence, when competent authorities like Drs. Leidy and Tuttle and others state that they have seen—as the authoress has also done—bronze weights of five or six pounds each, raised from the bottom to the top of an insulated glass jar through the influence, without contact, of a "vibratory lift," the time for careful and honest inquiry in the matter by critical European scientists would seem to have arrived. Large photographs, showing three positions of the weights in their transparent receptacle, when examined by a powerful lens reveal no evidence tending to vitiate the *bona fides* of experiment.

But the period of argument, of blind faith, or of captious incredulity, should have passed away; and as soon as the American physicist shows to an approved expert that he can raise a dollar or a dime six inches in the air or the water, in the manner described, it will not matter about incomprehensible language, or dictional idiosyncrasies; aerial navigation will be the *fait accompli* of the Victorian era, and John Worrell Keely, the discoverer, will owe to Mrs. Moore's remarkable book the great and generous recognition of his merits by the civilized world.

THE BATTLES OF SCIENCE.

The Battle with Fire—The Battle of the Forests—The Battle with Disease—Minor Notes.

[*The American Association for the Advancement of Science.*]

RECORDED BY CHARLES BARNARD.

The meetings of the American Association for the Advancement of Science are becoming more and more each year of wide general interest, by reason of the ever-growing application of science to useful work. Some of the meetings of the association have in the past been milestones, marking important steps along the path of science—white stones

shining with the light of new discoveries. All the recent meetings have had a steadily-increasing value, because of the educational effect of these annual meetings on the men of science. The forty-third meeting, held in Brooklyn, in August, 1894, attracted more than usual public interest, and was specially considered by the daily press, because of its educational value. At the same time, this forty-third meeting was not marked by any startling announcements of new discoveries likely to appeal to the popular attention. It appeared, rather, to show that the advance of science in the past year had been in the nature of a permanent occupation of acquired territory, rather than a brilliant march into new country. The papers read were largely reports of detail work, records of tests and experiments of value to the future student and experimenter, and historical surveys of certain fields of work, to show the progress already made. The allied associations that met at the same time, in Brooklyn, also afforded an opportunity to see where science stands to-day, and to give some hint as to the value of its conclusions to the actual work and business of the world. Of the two hundred or more papers read during the week in Brooklyn, three are here recorded, with some brief comment on the useful application of these branches of science to modern life and industry in this country.

Of the other papers read, by far the greater number were short records of research and experiment, chiefly of value to students in their particular fields. Of the longer papers, a few may be mentioned by title as of special value. Of these the address of the retiring President, Dr. William Harkness, at a General Session of the Association in the Academy of Music, on "The Magnitude of the Solar System," was, perhaps, the most interesting, from a historical point of view, as recording the methods used in measuring the distance of the sun. The paper summed up the result of all methods as giving the mean distance between the earth and the sun at 92,797,000 miles, with a probable error of only 59,700 miles, and for the total diameter of our system a distance of 5,578,400,000 miles. In Economic Science, a paper by Edward

Atkinson, entitled "A Forecast of the Future Commercial Union of the English-Speaking People," another by the same author on "The Evil Effect of Raising Prices by Depreciating the Standard of Value," and a paper by Henry Farquhar, of Washington, D. C., on "A Stable Monetary Standard," were of value to students of this science. In the Section of Anthropology, a long paper upon "Human Faculty as Determined by Race," by Frank Boas, of New York, attracted general interest. In the Section of Geology and Geography, a paper on "The Niobrara Chalk," by Samuel Calvin, of Iowa City, Iowa, was of interest to students of the geological history of the Northwest.

THE BATTLE WITH FIRE.

An important paper, from an economic point of view, presented in the Section of Chemistry, was read by the Vice-President, Thomas H. Norton, of Cincinnati, Ohio. The paper had the attractive title of "The Battle with Fire," and, while largely historical, was of the greatest practical value to the economist and taxpayer, as well as interesting to the chemist.

The total annual loss on insured property throughout the world is estimated at $200,000,000, nearly one-half this loss being borne by the property holders of the United States; our fire loss in 1893 being $90,344,075. In addition to this, it costs $20,000,000 each year to maintain our water-works and fire departments. The total loss caused by fires in the loss of wages, by accidents and death, cannot be computed; it is a very great sum every year. The actual loss of property alone amounts to twenty per cent. of the net profits on all the industries of the country. In reviewing the history of fire extinguishing and fire prevention, the paper briefly considered the history of fire-proof construction or slow-burning construction; the use of brick, stone, and metal in ships and buildings; the abandonment of light open-work like lathing and the growing use of solid and massive wood-work where wood must be used, and the substitution of metals for wood wherever possible. These things belong more properly to the

architect. Fire engines, in like manner, are the province of the fire engineer. Chemistry seeks to aid both architect and engineer, and the studies of scientists in this field have led to chemical engineering, or the science of fire control by chemical means as distinguished from mechanical means. The effective throwing of a stream of water upon a fire is a mechanical problem. The actual operation of water thrown on a fire is chiefly chemical. The province of the chemical fire engineer is to increase the efficiency of water thrown on a fire, and to prevent fires by causing inflammable materials, like wood or fabrics, to burn slowly, or ignite slowly, under ordinary fire temperatures.

One of the most curious applications of chemical means to the extinguishment of fire is the use of inflammable, quick-burning powders. These powders, when thrown on a fire, burn without explosion, and with a bright flame, produce a strong odor and a great deal of smoke, and evolve quantities of inert gas that tend to smother the original fire by cutting off its supply of oxygen. In small enclosed spaces, where there is little or no ventilation, they have proved effective. Seven different powders, all depending for their value upon a rapid production of gas, have been made the subject of investigation. Naturally, the attention of the chemical fire engineer has been given to the use of common water as a vehicle for conveying to fire chemical solutions which render the water more effective in smothering the fire and preventing the access of air to the burning material, in the production of aqueous vapor, or the mechanical protection afforded by coating the material with a fire-resisting skin or coat. To illustrate, the paper quoted an instance where a druggist extinguished some burning benzine by drawing a pailful of soda water from his fountain, and pouring it on the fire. Simple water would here have been ineffective. On this idea are founded all the various so-called chemical fire engines. They are machines, not engines, unless employing pumps to throw the prepared water on the fire. The principle on which all are constructed is the formation of a carbonated water under pressure, the gas formed in the enclosed vessel

serving to throw the carbonated water on the fire. The paper reported a number of chemical preparations used in addition to water, but the opinion seemed to be that the carbon dioxide commonly employed is the best. The history of this most important contribution of chemistry to the extinguishment of fire was briefly considered, and some account of six different forms of chemical extinguishers was given. A brief history of the various forms of hand grenades was also given. These are glass bottles containing solutions of various chemicals. These solutions aim to smother the fire by giving off gases, or by coating burning materials with an air-excluding skin. Their use is limited to very small incipient fires, and they are often rendered of no value by a failure to break when thrown into a fire. All the various solutions used in these grenades are exceedingly cheap.

The paper, having considered the history of these chemical fire appliances, then made a most interesting suggestion for future experiment and study. It would appear that chemists have practically brought this branch of the subject to a degree of perfection in which it did not seem likely that further important contributions to practical science would be made. Research and experiment have given us the chemical engine and hand grenade, and it might seem desirable to see if carbon dioxide could not be used precisely as water is now used in automatic sprinklers. In these sprinklers, pipes containing water constantly under pressure are placed near the ceilings of rooms. A fusible plug closes the outlet (or sprinkler), and when a fire starts, the plug melts and releases the water on the fire. While these sprinklers are effective and useful, they have the disadvantage of flooding the building after the fire is out, and often doing thus far more damage than the actual fire. A pipe system, open near the floor of apartments, could be used to convey great volumes of this harmless, inert gas into rooms where a fire had started, and thus smother it without injury to valuable property stored in the room, or on floors below. The actual making of the gas in sufficient quantities, its storage and

delivery, were not considered, and Professor Norton contented himself with making the suggestion, leaving to others to attack the practical side of the matter. However, in all science, it is the idea, the suggestion, that counts, because the man of science properly studies laws in preference to useful applications of laws, and prefers to add to the sum of human knowledge rather than spend valuable time in making knowledge useful. There are busy minds and hands always eager to gather up the sure facts and suggestions of science, and here is one of those cases where a valuable suggestion should produce, in the hands of practical men, something of real benefit to the people.

Allied to the use of chemistry to check and smother fire, is the equally important matter of preventing fire. Professor Norton's paper gave an exhaustive history of a very little known study. This is the treatment of wood, paper, and fabrics with various chemicals, to cause them to ignite slowly, or burn slowly, under moderate fire temperature. It is practically impossible to prevent the destruction of these materials in very high temperatures (that of a puddling furnace, for instance). Professor Norton, in his paper, and by the aid of actual experiments before the Section, proved that against the relatively low fire temperatures, it is now possible to render paper, cloth, and wood non-ignitable, or slow-burning. Beginning with the first experiments of Obediah Wild, in England, in 1735, he carefully traced the history of the very many experiments that have been made in the so-called fire-proofing of these materials. The researches of chemists in this field have been most thorough, and their experiments and results have received special attention within the past few years, so that the paper may be regarded as summing up the case of chemistry as an aid to the fireman, and showing that it is possible to practically "fire-proof" those highly inflammable materials. In protecting fabrics, used in dresses, scenery, etc., it is not alone necessary to cause them to ignite or burn slowly. The material must be cheap, and the protected cloth must not be too heavy or stiff. It must be easily bent without cracking the protective coating, and it must be

unchanged by washing or ironing, and the protection must be permanent. Of the very many fire-proofing solutions or preparations that have been under experiment, those containing sodium tungstate, the borates of ammonium salts, alone or in various mixtures, are chiefly used as best fulfilling all the requirements of a practical fire-proof cloth. Experiments during the reading of the paper proved that actual contact with moderate flame produced no effect upon protected cotton cloth, beyond a slight charring and blacking. It must be understood, however, that given a sufficiently high temperature, gases would be evolved, and these gases would burn and the fabric be destroyed. The point is, that the protected cloth will not burn in simple contact with flame, and even if actually burning, will go out and cease to burn the instant the cloth is taken away from igniting temperatures. With a preparation of sodium tungstate, cloth can be "practically fire-proof." For cloth that is to be worn, other preparations may be used. The chief point is, that cloth can be made fire-proof.

Paper in like manner may be made to burn very slowly or ignite slowly. Experiments made with various examples of prepared paper, showed that it could be made to burn very slowly, or to merely smoulder in flame, and cease to smoulder when the flame was withdrawn. A series of experiments with prepared wood were shown in connection with the reading of the paper, proving that slow ignition and slow burning could be secured, even in light pine wood, in contact with flame. Woods are now commercially prepared that are practically slow-burning or fire-proof. Professor Norton's paper was not alone interesting as a history of the efforts made in this important field of chemical engineering, but it was valuable as showing that we now have it in our own hands to protect our property against the enormous losses caused by preventable fires.

THE BATTLE OF THE FORESTS.

The paper read at one of the evening sessions, by Prof. B. E. Fenrow, Chief of the Forestry Department at Washington,

was profusely illustrated, and, while technical in its character, treated of subjects that are of vital importance to all the people. After an instructive and exhaustive history of the rise and progress of the vast forests that once covered the larger part of this country, and after showing the once enormous extent of our forest wealth, Professor Fenrow took up the subject of man's interference in the great century-long battle that always goes on in all wooded lands between the weak and the vigorous trees, each striving for a foothold in the soil and a chance to enjoy sun and air.

Forest growth begins on barren sands or bare rocks, by the starting of shrubs and small plants, that, dying, leave their remains to form a humus or soil in which better and larger plants may grow. Trees create soil through their own decay and death, and by catching and holding water and drifting material of all kinds. A forest in active operation creates its own soil at the rate of one foot in five hundred years. The lumberman can strip an acre of forest of its trees in a few days, and leave the soil that it cost two thousand years to lay down, to be totally ruined and destroyed in a few months. The natural processes that instantly follow the cutting off or burning of a forest area, and the correct methods of controlling them and the proper means to be used in saving our forest wealth, form the Science of Forestry. A rapid and graphic study of this science made the most interesting and valuable part of Professor Fenrow's paper.

Rain falling on forest-covered land meets with an elastic surface. The leaves break up its down-pour, and the trees and the vegetable growth under them act precisely as a sponge, checking the on-rush of the water, holding it back, and allowing it to seep slowly away, without injury to the soil. Forests act as moisture holders, and keep the air damp by checking too rapid evaporation. Drying winds and the direct sunlight act more slowly in woods than on bare hillsides. Strip the land of its trees by axe or fire, and the rain strikes the soil with full force, accumulates in swift rivulets, plows up the soil, and sweeps it away to lower levels. The

process is simple; the results are enormously destructive. Streams that in forests ran evenly throughout the greater part of the year, become capricious and uncertain, now raging in destructive floods and torrents, now dwindling to mere rivulets, of no value to the miller or boatman. With incredible rapidity the costly soil of mountain slopes is swept away and lost, after the forests disappear. The soil gone, the rains sweep down loose rock and cover the once fertile valleys with wastes of sand and gravel. The process begins everywhere the moment the trees are gone, and increases in destructiveness from year to year, leaving stony wastes on the mountains and a wilderness in the valleys. That we do not see more miles of ruined land and sterile mountain side; that our country is not as impoverished and desolated as Spain and parts of France, is simply because we have not yet gone far enough. The process has begun already, on a gigantic scale, in several of our States, and it is only a question of time when the States, combined or singly, must interfere and control the farmer, the miner, and lumberman, who are now so barbarously destroying the present and potential wealth of the country. Well may foreign writers, seeing our wasteful methods of tree cutting, and viewing our inexcusable forest fires, say that we are "a barbarous and uncivilized people."

The science of forestry offers both prevention and cure in forest control and reforesting. Reforesting, or restoring land to a tree-growing condition, is expensive and comparatively slow, so that its general adoption upon a large scale in this country is perhaps doubtful. Forest control we can and must institute at once.

The replanting of forests as practiced on the barren and valueless mountains of France was fully described in Professor Fenrow's paper, and is interesting, as it is quite possible that some modifications of it may yet prove profitable wherever the price of land will warrant tree culture. These mountains being absolutely denuded of all soil, are washed by every rain, the *débris* covering the farm lands below. The first step is to check the too rapid flow of storm-water,

by building little dams of wicker work on the slopes to catch the water, and compel it to flow slowly in a series of pools and tiny waterfalls. In these slack waters, or catch basins, the drift-sand gathers and forms little plateaus of soil that in a very short time will sustain a growth of small hardy trees. The roots bind and hold the new soil, and in a comparatively short time the barren hillsides are green with infant forests. Where the slopes are steep, and the damage has been great, masonry dams are used, and soil is carried up and put behind the dams to give a foothold to the young trees. Such prepared hillsides at once begin to act as water-holders, restraining floods, and preventing droughts; in fact, restoring forest conditions. Whether this work will pay here is simply a question of the cost of labor, and the value of the land, the water, and the lumber crop. It pays some return at once, by preventing further destruction of good land, and by saving the water and controlling the streams. In New Jersey, where water is money, it would undoubtedly be profitable to reforest many square miles of now valueless mountain sides. There can be no question that in time it will repay to reforest barren mountain sides that are in reasonable reach of large cities, because of the value of the water restrained and restored by forest growth. Ultimately, the lumber crop would be added to the water crop.

Concerning the control of forest lands, Professor Fenrow's paper was most impressive. We must do it, or some day meet a lumber and water famine, and see our valley farm lands ruined; and our rivers obstructed, and our cities water-starved. Forest control means simply intelligent supervision over the cutting of trees. The farmer and forest land owner claims he has a right to do as he pleases with his own. Such right implies no injury to others. In the case of forest lands, the right to cut down the trees conflicts with the rights of the entire community, and the rights of posterity—and posterity has moral rights, if not legal rights. Fortunately, forest control is not the mere suggestion of science. Forest control is a science itself. Just as in France the science of reforestry is carried on as a function of government, so in Germany

forest control is a proper and profitable branch of the general government. Trained foresters, the police of the woods, patrol all forest lands, protect the trees from fire, decide what trees shall be cut each year, and how and when every single tree shall be felled. Poor and undesirable species are culled out, and valuable commercial varieties saved and protected till of merchantable size. Bare hillsides, and all cheap or comparatively valueless agricultural lands, are replanted and made to yield a timber crop where no other crop will grow. In this country, State control of forests must come, and come soon; and the Public Forester must soon stay the hand of the farmer and lumberman. The question is one of vital importance, involving many diverging and apparently conflicting interests. The highest skill and the widest knowledge must be brought by our State legislators to bear on this question of our forests. Forest preservation does not mean shutting up the woods to useless decay and overgrowth. Intelligent forestry means simply control; preservation and protection first, and then the proper and business-like cutting of this, the greatest crop that the soil has ever yielded. As we now stand idle, while the forest fires bring on us a loss of millions every year, and while the unintelligent wood-chopper is permitted to do as he will with what is not truly his own, we are justly charged with being "a barbarous people." "Woodman, spare that tree," was once a sentiment. It is now a command of scientific duty.

Closely allied to the paper by Professor Fenrow were a number of short papers read before the American Forestry Association, that held its sessions during the week of the American Association meetings. The eighteen papers submitted had all, with one exception, immediate connection with the science of forestry. The one exception was a descriptive illustrated paper by Horace C. Hovey, of Newburyport, Mass., upon the petrified forests of Arizona. This paper, while entertaining, as an account of a visit to these curious geologic remains, had no direct bearing on forestry as a science. Its most valuable point in the interest of geology was the wanton destruction of these curious and beautiful

relics of ancient forest life by persons who only see in them so much money to be won from their ruin and extinction, and the suggestion that the law should be invoked to protect this remarkable deposit before it be too late.

The remaining papers were all written by experts in the science of forestry, and were valuable as showing the present position of the science in this country as far as it relates to the actual control of our woodland wealth. The forests in all our States are now being made the subject of careful study, both by individuals, scientists, and Forestry Commissions under State and Federal control. In some instances the matter is under the care of State Geologists and State Experiment Stations. The study of forest fires and their prevention is also the subject of earnest study in several States, notably in New Jersey, where a complete system of fire protection is under consideration. The consensus of opinion at the meetings seemed to be that we must copy the forestry laws of Germany, and establish regular paid forest fire departments and patrol. All the papers of this association, while almost wholly technical, seemed to be worthy of the most earnest public attention, because it was evident from the tone of the discussions of the association that the great need to-day in this country is forest education. It is not that the great mass of the people are indifferent or careless; it is not that they are willingly allowing the lumberman and farmer to ruin the public wealth invested in trees, but that the people do not realize how serious the matter is, how gigantic is the annual commercial loss occasioned by forest fires and how ill directed our forest depletion. The country seems well wooded to the uninstructed eye. The desolated hill country, bereft of its trees, is seldom seen, and the demand for wood is enormous. These things have led to a certain public indifference that is plainly reflected in all our legislatures, and it was clearly the desire of the Forestry Association that educators throughout the country should bring the public to a realizing sense of the value of forestry science in saving our woodland wealth before it is completely lost.

THE BATTLE WITH DISEASE.

Before the American Association of Microscopists, Dr. W. W. Alleger, Instructor in Bacteriology at Howard University, Washington, read a paper on "The Limitation of Tuberculosis." The title exactly defines the scope of Dr. Alleger's paper. It was to define and explain the most recent views concerning the limiting or preventing of the spread of this disease. The bacillus tuberculosis varies in length from 1.5 to 3.5 micro-millimeters, and appears as a rod-like vegetable growth in the sputum and lungs of persons suffering from consumption. It does not appear able to grow and multiply outside the tissues of a living animal. On the other hand, it appears to be able to survive for months, perhaps years, in the dry dust of dark corners, cracks, or crevices of walls and floors in rooms, and probably in fabrics and clothing kept in dark closets. The sputum, carrying the bacilli, may dry away to dust, and the dust float about in the air, and the spores will still survive in the dust, at rest or suspended in the air as microscopic seeds, ready, when once planted in a suitable medium, to start again into life as bacilli.

The spores of the bacilli may thus be inhaled or absorbed in milk, and ultimately reach the lung tissue in great numbers. If the conditions are favorable, if the tissues, weakened by exposure, or cold, by other diseases, or from any cause are susceptible to the spores, they may start into life and produce the bacilli in great quantities, and the disease be thus established. If, by reason of excellent general health, freedom from debilitating disease or conditions, the tissues resist the spores, they may fail to grow. It would seem, therefore, if hygienic conditions were, according to Dr. Alleger, favorable, the disease may be, and is, continually resisted. If the conditions are unfavorable, the first exposure to the spores may lead to the starting of colonies of bacilli in the tissue of the man or animal. It is thought that this has given rise to the idea that consumption can be inherited. The unavorable conditions, the weakened constitution (weakened rom other causes) may, indeed, be inherited, and give good

soil for the spores to germinate in, and the disease appear to be thus inherited. Its actual inheritance seems very doubtful.

In the treatment of the bacillus nature has given us one simple remedy. Direct exposure to the sunlight will destroy the bacillus in a few minutes. Sputum containing it may be rendered harmless by direct sunlight in an hour or two, and even bright diffused daylight will slowly destroy the vitality of the bacillus. Fire and heat also destroy the vitality of the bacilli and their spores. The practical applications made by Dr. Alleger of these facts are of importance. First, of the sputum of consumptive patients. It should be instantly received, not on cloth, but on paper, and the paper at once burned. Handkerchiefs of paper should always be used in preference to those of any fabric, unless, like the paper, they are at once burned. No handkerchief, bib, or other article soiled with sputum should be left to dry. In fact, the sputum must be invariably destroyed before it can dry, because the spores may then float in the air as microscopic dust, or cling to walls, furniture, or clothing, be carried in cars, state-rooms, or carriages, to be shaken off in the air and inhaled by persons susceptible to their influence. Table-ware should be washed in boiling water, linen burned, and bedding disinfected or destroyed. Persons affected by consumption should not be allowed to work in close apartments with others, both on account of danger to themselves by reinfection and on account of exposure of others. Hospitals for consumptives should be separate wards or buildings; and in private dwellings patients should be kept in bright, sunny rooms, alone, and not in close companionship of others. Dairies and slaughter-houses should be rigidly inspected and infected animals killed and their meat and milk destroyed. Public disinfecting plants should be established in all cities for the free cleaning and disinfecting of the clothing or other material used by consumptives. Good manners forbid spitting by any one upon the floor or sidewalk at any time. The spitting by consumptives upon the floor or sidewalk is criminal. Education in this respect must teach that

science in this instance commands good manners. Public spittoons, from the point of view of this valuable paper by Dr. Alleger, should be made of paper and burned after use. By these methods consumption may be greatly lessened, and, perhaps, ultimately stamped out.

Of the shorter papers, the greater majority were chiefly interesting as records of experimental research in fields useful only to the experimenter. Incidentally, a few minor points of general interest may be noticed. In the Section of Physics a short paper by Alfred Springer, concerning the results obtained in making violins of sheet aluminum, was rather negative than positive. A violin exhibited during the reading of the paper, proved to have a loud but not attractive tone. The instrument was light, and apparently an exact imitation of a wooden violin, and yet, by the nature of its material, it did not, and could not, give the peculiar "wood tone" characteristic of a fine wooden violin. The difficulty seemed to be in the uniform thickness of the sheet metal. The back and belly of a wooden violin are of varying thickness, and no ribs or other additions to the sheet metal would exactly imitate this feature of even the most common wooden violin. The speaker said, in his paper, that aluminum sound-boards differed from those of other metals, and were analogous to those of wood in not producing overtones out of tune with the fundamental note. This advantage did not seem to be sufficient to overcome the defects inherent in a sheet metal violin.

In the Section of Botany, a paper read by B. T. Galloway, on "The Growth of Radishes as Affected by the Size and Weight of the Seeds," was valuable to the seed buyer and seed dealer, as showing the difference between large and small seeds. The radish seed sold by seedmen vary greatly in size. The radish is a plant that quickly matures, and is a good subject for experiment in this direction. The paper reported, as the result of a series of greenhouse experiments, that large seeds will mature their crop faster and more evenly than small seeds, 85 per cent. of the total crop maturing at the same time. The average that can be gathered

from a crop from small seeds, is only 50 per cent. In point of repeated crops or successive returns from the same ground, large seeds produce five crops while small seeds produce four. In view of the fact that seedsmen are advertising "selected," "screened," and "extra choice" seeds, these facts are of value, as showing that seeds that are really "selected" or screened for size, have an actual commercial value from 20 to 30 per cent. greater than the common, uncleaned stocks of seeds. The experiments tried on the radish would probably produce the same results in other seeds.

A short paper read before the Section of Economic Science by Byron D. Halsted, on "Weeds as Related to Civilization," was of interest as showing that the modern development of rapid transportation by land and sea had tended to distribute the seeds of weeds over all countries, so that the weeds of one country become common in the soil of many other countries where they are not natives. The exchange of agricultural products being rapid, the seeds of weeds carried with other materials maintain their vitality only to germinate in new soils and spread over new fields. The so-called "Russian thistle" is an example of the rapid spread in this country of a foreign weed. The paper reported a very rapid increase of weeds in all civilized countries, and suggested that all possible means should be used in agricultural districts to exterminate weeds along roadsides and in unoccupied lands; laws against weeds should be enforced, and the public schools should be used to instruct the rising generation how useless plants and weeds can be exterminated.

A paper upon an allied subject, by Professor L. H. Bailey, was entitled, "The Struggle for Existence [among plants] Under Cultivation." The point brought out by this paper is of interest as explaining the enormous number of novel forms of garden plants and the rapid increase of new types and varieties. Under natural conditions, in a wild state, through the struggle for existence, in which only the most fit ever survive, a variety or type maintains itself by the survival of its strongest individuals. The fight is between type and

type. The moment a type is brought under cultivation, wholly new conditions prevail. Cultivation cuts off a very large percentage of all the seeds that germinate. Fewer survive, whether the most fit or not. The type, protected in the struggle with other types, is left free, and the struggle becomes one of individual plant against another, instead of against the common enemy. The tendency is, therefore, to induce variability of type. Individuals of the species become special, and tend to create variations from the species. The struggle under cultivation may be even more intense than in a wild state, and the most vigorous plants perpetuate individual characteristics and thus establish new types.

BRITISH ASSOCIATION ECHOES.

The *clou* of this year's gathering of the British Association in the stateliest, most picturesque and most interestingly historical of all English towns was unquestionably the announcement by Lord Rayleigh and Professor Ramsay of their discovery of a new gas in the atmosphere. Elsewhere in this number of THE NEW SCIENCE REVIEW we give the opinion on this subject of Professor Dewar, of the Royal Institution, London. This being the case, we shall confine ourself here to a rapid passing reference to it.

Briefly put, the discovery comes to this. The two learned men, whose names have been literally "flashed from pole to pole," have found that, after all the oxygen and all the nitrogen have been removed from a quantity of pure dry air, a residue is left, amounting to nearly one per cent. of the whole, which has a density greater than that of nitrogen, and gives a spectrum with a single blue line, much more intense than a corresponding line in the nitrogen spectrum. Up to now we are in ignorance as to whether this new substance is or is not an element, and as to its physical and

chemical properties. Its chemical inertness has enabled it to escape observation for so long a period, and also makes further research difficult. The whole circle of the sciences cannot fail to be affected by the discovery which has made the Oxford meeting of 1894 notable.

Most beautiful were the experiments (also in the Chemistry Section) of Professor J. J. Thomson, indicating that, in all probability, if a gas were perfectly dry no electrical discharge could take place through it, however high the tension.

There were more foreign scientists present at the Oxford meeting than at any previous gathering of the Association. Of much interest was the paper contributed by Dr. A. Bernstein (Berlin) on "The Chemical Action of a New Bacterium in Milk which Converts the Proteids of Sterilized Milk into Peptone." *On dit*, that the new bacterium is much used for ripening cheese. Papers in the Chemistry Section were also contributed by Dr. S. Rideal, Professor Clowes and Dr. Haldane; but we have only space to mention them, so great is the pressure on our pages this quarter.

The Section devoted to Geology was rather uninteresting. The papers were many in number, but nearly all were unattractive. Those who perused Major-General Drayson's article in our first number, will be pleased to hear that the Rev. J. F. Blake discoursed on "The Mechanics of an Ice Sheet," while Mr. Edward P. Culverwell submitted a paper on "An Examination of Croll's and Ball's Theory of Ice Ages and Genial Ages," and Professor Bonney's paper was on "The Probable Temperature of the Glacial Period."

There were many papers on Applied Physics, and intense interest was taken in the paper read by Lord Kelvin, on "The Electrification of Air by the Removal of Water from it, and on the Resistance Experienced by Solids Moving Through Fluids." We gathered from these essays that progress is still being made toward a knowledge of the ultimate cause of electrical disturbances of the atmosphere, and of the perfect shape for the hull of a vessel. Very notable was Professor Förster's paper on "Displacements of the Rotational Axis of the Earth," with its expression of belief that "the North

Pole wanders through about fifty feet only between its extreme positions." It was only paying the Professor a well-deserved compliment for the Section to ask the Association to print the paper *in extenso.*

In this same Section was the Department of Meteorology; and it must have been humiliating to the *Times*' able expert to have to admit, that "the numerous reports on work done on Ben Nevis and elsewhere showed that we are holding our own, but, compared with present activity in America and on the Continent, British meteorology was distinctly deficient."

In Section D papers were read dealing with the minute structure and physiology of the animal and vegetable cell; Professor Strasburger's contribution attracting the keenest attention. "Chlorophyll in Animals" served as a text for Professor Ray Lankester.

At one meeting no fewer than five papers were read, all dealing, in one way or other, with Evolution and Darwinism. Professor D'Arcy Thompson ("Some Difficulties of Darwinism,") suggested that the mechanical and mathematical principles of growth itself may have affected the form of animal life. Professor Riley (Washington) dealt with the habits of ants, bees, wasps, and termites; his argument being, that in this case the struggle for existence of the colony, as a whole, must be substituted for that of the individual. We, unfortunately, missed the gathering at which all these papers were submitted. In the *Times* we find this interesting comment on Professor Riley's remarkably able paper: "An interesting point was made by Professor Haycraft, to the effect that the true *rôle* of sex was to keep down variation—that by the combination of two individuals to form a new individual, a mean between the two was always obtained, and that in this way the race was kept constant; whereas, if that new individual could be produced from only a single parent, the limits of variation would be unduly extended."

Professor Osborn (New York), in his interesting paper, "On Certain Variations met with in the Dentition of Fossil Mammals," showed how two teeth might eventually come to

resemble one another closely, although the stages through which they passed had been widely different. In the animated talk which followed the reading of Professor Osborn's paper, Professor Ray Lankester laid stress on the fact that the younger biologists of to-day did not pay sufficient attention to Darwin's works; and, judging by the applause with which this complaint was greeted, the professor's opinion was generally shared.

Captain Wharton presided over the Geographical Section, and gave an address which was listened to with deep interest. Current polar exploration was naturally to the fore, Colonel Feilden's paper thereon being much applauded. A paper on "Oceanography," read by Mr. Buchanan, described the researches of the Prince of Monaco in the North Atlantic and Mediterranean during the summer of 1894. The name of the ruler of the miniature principality, which requires an army (!) of eighty men only for its protection, is known to the world generally as that of the Independent Sovereign who draws the larger part of his income from the roulette and *trente-et-quarante* tables. Scientists, however, recognize in the Prince *un homme sérieux*, whose delight it is to scour the seas on researching expeditions in his yacht, the Princess Alice—so named, by the way, after the Prince's second wife, the Duchesse de Richelieu, who is so wealthy in her own right that she wishes her consort to make short work of that eyesore to the Riviera, yclept the Casino. Many members of the Association were heard to express a wish that the Prince had been present at Oxford in *propriâ personâ;* we hear it is likely that he will endeavor to assist at next year's gathering, of which Ipswich is to be the scene.

The paper read by Mr. Buchanan, F. R. S., on His Highness's behalf, described in well-chosen phraseology the scientific researches of the Prince in his yachting excursions. Careful soundings were taken in the course of the voyage, and it was found that for a considerable distance eastward from Gibraltar and Ceuta the surface water comes mainly from the Atlantic. The surface temperature varied from 15C. to 17.4C.; but under the influence of hot winds the

thermometer rose in the water to 28C. and 29C. The Prince introduced several improvements in sounding and dredging operations, and the dredge was successfully employed to great depths of water. From a depth of 2,230 mètres eighty-nine black ground sharks were brought up of a species until now considered to be exceedingly rare. The greatest depth at which the dredge was used was 3,610 mètres on July 8, 1894, when some fishes were brought up which have still to be identified. Life was shown to be abundant where it has hitherto been supposed to be scarce.

Highly important was Dr. Haldane's paper on "The Causes and Prevention of Suffocation in Mines." As the result of most elaborate investigation, he arrived at the conclusion that in colliery explosions the deaths from suffocation were due, not, as was generally supposed, to carbonic acid gas, but to the preponderance of nitrogen and the deficiency of oxygen. Life could be saved if the colliers could be supplied with oxygen for an hour or so; and he had devised and exhibited an apparatus for enabling a man to breathe oxygen, of which sixty litres were compressed into a half-litre bottle with tube and regulating taps, supplemented by a wire compress for the nose to prevent breathing through that organ. Professor Rutherford (who presided) said that Dr. Haldane had greatly increased our knowledge, and had offered a practical solution of a difficult problem. He presumed the proposal was that every miner was to be provided with the apparatus. If saving of life should result from the adoption of the apparatus, Dr. Haldane will have earned the gratitude of humanity.

The new science of limnology was not neglected. There were papers by Dr. Mill, on the English, and by M. Delebecque, on the French Lakes. Very few agreed with Mr. Yule Oldham's argument that South America must have been discovered by the Portuguese some fifty years before the voyage of Columbus; more especially as Mr. Oldham founded his contention solely on the basis of a dubious outline of land on Bianco's map of 1448.

In the Section devoted to Economic Science, a large number of papers were read, and Professor Nicholson's lecture on "Socialism" proved a great attraction. Mr. Edward Atkinson's paper on "The Evil Effect of Raising Prices by Depreciating the Standard of Value," was much appreciated, dealing, as it did, mainly with the course of affairs in the United States. "Whatever" (remarked the *Times'* commentator) "may be thought of the criteria applied and the conclusions come to, there can be no doubt of the value of the mass of facts brought together and co-ordinated by Mr. Atkinson."

Very pleasurable were the memories of this ancient seat of learning which the visitors took away. It was left to Professor Barker (Pennsylvania) to publicly return thanks for the hospitality which had been accorded by the university, the colleges, and individuals which had done so much to make the meeting a success. The professor sympathetically remarked that he had enjoyed the privilege of being a guest at Merton College, of the warden and Miss Brodrick, and to that college, as also to Balliol, New College, Magdalen, Lincoln, Jesus, Corpus, and Brasenose—to the Duke of Marlborough, the Mayors of Woodstock, Wallingford, Windsor, and Abingdon, the Great Western Railway, and other bodies and individuals, he desired to express grateful acknowledgment. To this list, he begged respectfully to add her Majesty the Queen. Needless to say how enthusiastically the professor's observations were received.

THE FRENCH ASSOCIATION MEETING.

The annual congress was held at Caen, one of the most interesting old towns in France; the President being M. Mascart, member of the Academy of Sciences, Director of the Central Meteorological Bureau, Professor at the College of France, and President of the National Defence Commission of Inventions, recently organized for the purpose of examining those inventions of the well-known M. Turpin which have provoked, and continue to provoke, so much criticism in

French scientific circles. M. Mascart's opening address, which lasted nearly the whole of the first day (!), was particularly interesting to Americans, for it was an enthusiastic panegyric of the "private initiative in the realm of science characteristic of the United States."

A contributor writes:

"M. Mascart's paper was a most brilliantly written one, and the numerous references to American liberality in scientific and educational matters were warmly applauded; the more so as private initiative in such matters is almost unknown in France. An excellent abstract of the paper was published it *Le Temps*, but even that *résumé*, if fully translated, would occupy fourteen or fifteen pages of THE NEW SCIENCE REVIEW. Your readers will understand the elaborate nature of M. Mascart's address when I state that it began with a reference to the founding of the town of Plymouth by the English Puritans, and then dealt with the establishment of Harvard University. Harvard was dealt with in great detail; and then came references to Chicago and its Fine Art Institution. The cost of that palace was given as six hundred thousand dollars, 'and,' naïvely remarked M. Mascart, 'it is necessary to quote figures, because in America they are the measure of everything,' a humorous reference which the *savants* received with a burst of good-tempered merriment. Chicago's first university was alluded to, and all credit was given to Mr. Rockefeller. 'That university,' said M. Mascart, 'has a great future before it, and it will mark an era in scientific progress.'

"The Armour Institute came in for a glowing, though somewhat briefer eulogy, the President remarking that 'it bore a name which the provision trade had made known all over the world: that is sufficient to tell us where the dollars came from! The same methods,' he continued, 'were to be found in all the States, young and old alike; but it would take a volume to give an idea of the generosity of American citizens in respect of all kinds of educational establishments. America has a place of honor for its astronomical discoveries, and its fame increases year by year. In all the

sciences its progress is rapid; and very soon the United States will have no cause to envy any of the older nations, except for their history.' This was confessedly a very happy and generous remark, and M. Mascart's words seemed to find a ready echo among his delighted auditors. His peroration was a glowing one, and I cannot refrain from appending it, remarking, however, that its effect is somewhat diminished when robbed, as it is, of the life infused into it by the amiable President's eloquence.

"'We must all agree that it is a grand spectacle to see a people, whom it is easy to accuse of greed of gain and unbridled worship of lucre, display so general a care for the public weal, whether by the continued action of the citizens or by the founding of princely institutions; whether it is a question of charitable establishments, model hospitals, fine art institutes, elementary schools, professional schools, and institutes destined to turn out engineers and mechanics; or whether it is a question of teaching, having for its object the intellectual elevation of the mind, without any reservation as to commercial profit. Energetic and courageous men rapidly make fortunes in that country; they are not preoccupied to the same extent as we are with the desire to bequeath the whole of the benefits to their heirs; while others attach importance to the titles of nobility, the Americans seek to confer a lustre on their names by permanent works, which shall be either useful to the community at large or redound to the glory of their country.'"

After this gratifying recognition of the scientific life of the United States—a picture, remember, drawn by M. Mascart from his own personal experiences—the learned President broadly traced the history of electrical science, of which he is to-day one of the most eminent representatives. He showed his hearers, in a striking manner, how the most abstract scientific theories lead to the most practical applications. The various electrical industries—more marvelous than all others, as viewed by the light of recent discoveries—readily lent themselves to M. Mascart's able demonstration, which cannot be too often repeated in order to encourage and

stimulate the zeal of those *savants* who labor for the benefit of humanity, too frequently, alas! without themselves participating in any of the tangible products of their toil.

THE LIQUEFACTION OF HYDROGEN.

It is worthy of note, in these days of well-nigh universal culture, that there is only one daily journal in London which attempts to deal, in anything like an adequate and reliable manner, with scientific questions. That solitary example of literary-scientific journalism is the *Times*, to the pages of which we must all turn if we would keep ourselves well posted in the advance of the sciences generally. Those of our American readers who attended the Oxford meeting of the British Association in August, could not fail to have observed the vast superiority of the *Times*' reports of the proceedings over those of any other paper. So it is with its legal reports, which, as all lawyers will agree, are the only accounts of what happens in the Courts of Justice which are worth reading, so invariably accurate and impartial are they.

These remarks are suggested by a perusal of the valuable account of some recent experiments in the liquefaction of hydrogen, which appeared in the above-mentioned journal on the 1st of September. We have, however, a complaint to make, *viz.*, that the article is unsigned. We (who are, perhaps, a little behind the scenes) can give a guess at the authorship; but the world at large can form but little, if any, idea on the subject. This is the more to be regretted, as we do not hesitate to say that the report of the experiments in question is of the highest importance and the greatest value.

The writer begins by ingeniously drawing an analogy between "the strenuous efforts now being made by physicists to approach the zero of temperature, and the numerous attempts that have been made, or are now being made, to reach the North Pole. . . . . In both cases," he proceeds, "success may be said to depend upon equipment, persistency, and the selection of the right road. In neither case can the

anticipated results be considered as likely to be of immediate practical value. The North Pole will not be the signal-post of a trade route, and the condensers of our engines are never likely to reach the zero of temperature. If the latter could be obtained, however, the results would be highly practical, because we should then completely transform heat into mechanical power, instead of getting only ten per cent. converted by our present means of working. The solution of the problem of the North Pole will add greatly to our knowledge of physiography, and the approach to the zero of temperature will open out fields of investigation where matter and energy can be examined under new conditions. The parallel between getting to the Pole and reaching the zero of temperature, breaks down, however, when examined a little more carefully. There seems to be no reason why man should not attain the 90th parallel of latitude as well as the 75th, but in the case of temperature there are strong grounds for the belief that the zero can never be reached. The temperature of celestial space can only be approached in the laboratory, yet the nearer we get to it the more important physical problems become."

Liquid air or nitrogen is the agent most successfully used in these investigations. Hydrogen is the only remaining gas which has not been liquefied, although the text-books sapiently state the reverse! So much for the value of such short cuts to knowledge!

The possibility of making a gas pass into the liquid state depends (says the able writer in our London contemporary), upon our being able to get below the point of temperature known as the critical point. Unless this point is reached, no amount of pressure can force the gas into the liquid condition. Now, hydrogen has a critical point of about *minus* 240°, and the question is,—How can we attain such a temperature, seeing that liquid air or nitrogen only enables a temperature of *minus* 200° to be reached? How can these 40° or 50°, as the case may be, be bridged over? This can only be done by constructing a new substance, having a critical point of *minus* 200°, or some 50° lower than nitrogen, which is the most volatile known liquid. Such a body can be made by liquefying a gas composed of hydrogen mixed with ten per cent. of nitrogen. This is the direction in which Professor Dewar has been lately pressing forward his investigations, and the new results give hope of further advance.

The really serious question is the extremely small proportion of the liquefied material that can be collected in open vessels. In order to understand this, it is necessary to keep in mind that, when a substance is near its critical point, it has a very small latent heat of evaporation, but a very high specific heat. It follows, therefore, that, in order to get the liquid cooled by its own evaporation from near its critical temperature to its boiling point, a very large proportion of the liquid produced under high compression in the refrigerating apparatus has to be sacrificed. Thus, for instance, one pint of liquid air collected in one of the well-known open vacuum vessels necessitates the liquefaction of some three pints of liquid in the apparatus. In other words, two-thirds of the original amount of liquid produced has to evaporate in order to procure the remaining third at its own boiling point. The proportion of the resulting liquid in each case depends, as above stated, on the latent heat of evaporation and the specific heat of the particular liquid—if we neglect for the present the serious question of cooling the vessels—and the loss of heat by radiation and conduction.

All our present experience confirms the view that the latent heat of evaporation is proportional to the absolute critical temperatures or, what is about the same, to the absolute boiling points. As the absolute critical point of of hydrogen is about *minus* 240°, while that of nitrogen is *minus* 128°, it is clear that the latent heat of liquid hydrogen would only be one-third that of liquid nitrogen or air. Further, analogy leads us to the conclusion that the specific heat of liquid hydrogen is very much greater than that of liquid nitrogen or air. The combined result must therefore be that, if practically only thirty per cent., as above described, of liquid nitrogen or air can be collected, a very much smaller amount of hydrogen, say from one to five per cent., is all we can anticipate as the yield by similar methods of manipulation.

Assuming that we had such a liquid, its use as a cooling agent would, indeed, be very expensive, since its cost may be taken as at least twenty times the cost of liquid air. One thing, however, can be proved by the use of the gaseous mixture of hydrogen and nitrogen, *viz.*, that by subjecting it to high compression at a temperature of *minus* 200° and expanding the resulting liquid into air, a much lower temperature than anything that has been recorded up to the present time can be reached. This is proved by the fact that such a mixed gas gives under these conditions a paste or jelly of solid nitrogen, evidently giving off hydrogen, because the gas coming off burns fiercely. Even when hydrogen containing only some two to five per cent. of air is similarly treated, the result is a white solid material (solid air) along with a clear liquid of low density, which is so exceedingly volatile that no known device for collecting it has been successful. To attain such a result, it is necessary to liquefy and expand more than one pound weight (or about seven cubic yards) of hydrogen gas.

Knowing the difficulties from having to deal in the liquid state with the accumulated small impurities in such large amounts of gas, Professor Dewar will not declare that he has had pure liquid hydrogen in one of his vacuum vessels, although what this liquid can be except hydrogen it is impossible to say. The future progress of these costly and difficult experiments must

depend very much upon questions of outlay, and it is to be hoped that the public will not assume that the endowment so handsomely given to the Royal Institution by Mr. Ludwig Mond, for the maintenance of a public laboratory of research, to be called the Davy-Faraday Laboratory, can be used for the prosecution of such investigations.

We cordially re-echo the hope expressed by the *Times*, and trust that no difficulty will be experienced in getting together the required funds. This is one of those scientific problems in which all the world is interested, and to the prosecution of which all nations can subscribe. The *Times* has brought forward a subject of much scientific importance at a most *à propos* time—a period when the echoes of the great gatherings of scientists in America and England are still ringing in our ears, and it affords us the utmost pleasure to second the efforts of the great British newspaper in the direction herein indicated.

THE NEWEST EXPLOSIVE—"SCHNEBELITE."

Within the last few months the War Departments of all the first-class powers have been approached with a view to their adoption of the new explosive, to which the inventors, the Abbé A. Schnebelin, and his brother, G. Schnebelin (formerly an officer in the French Artillery), have given their name. "Schnebelin," or "Schnebelite" powder has for its basis chlorate of potash, no other dangerous chemical compound being used in its manufacture, and it is made in three forms—for military rifles, for sporting guns, and for mining purposes. It goes without saying that superiority over all other explosives is claimed for it, and certain it is that experiments in France, Belgium, and England have been most satisfactory to many experts. A leading merit of Schnebelite is its safety from accidental explosion by any rough usage it may get in the process of manufacture, or during its use or its transport; while the energy developed when it is fired from the new magazine rifle, or from an ordinary double-barreled gun, compares very favorably with that obtained with the most modern explosives employed in these arms—*e. g.*, Cordite, Lebel powder, Wetteren L3, etc.

Some of its other advantages may be briefly enumerated. Its manufacture is simplicity itself; it is adapted for all war, sporting, and mining purposes; it is almost smokeless, with a very slight recoil; it is not permanently damaged by heat or wet; the gun does not foul or become oxidized; no noxious gases are produced from its combustion; it is very cheap to make; a temperature of 540° Fahrenheit is required to produce combustion; when a lighted match is applied to it in its unconfined state it simply burns, no explosion being produced; the pressure developed by the charge of Schnebelite, required to give the normal velocity to the bullet fired from a military rifle, is from 1,600 to 1,800 atmospheres, as compared with 2,600 to 3,200 atmospheres, the pressure developed by charges of other explosives when the same velocity is imparted to the bullet, and as compared with the best dynamite its force is as 55 to 45, or twenty per cent. greater, while it does not pulverize the surrounding rock as dynamite does.

The inventors assert that Schnebelite can be manufactured and sold at least fifty per cent. cheaper than any other known explosive of a similar character. Its adoption by the French Government would, it is believed, result in a saving of 50,000,000 francs per annum.

"THE NEW ELEMENT OF THE ATMOSPHERE."

Considered by Professor Dewar.

Royal Institution, London, August 15, 1894.

In the *Times'* report of the important paper communicated by Lord Rayleigh to the British Association on a new gaseous constituent of the atmosphere, no mention is made of the evidence of the existence of such a body drawn from well-known phenomena occurring during the liquefaction of air. If a vessel be cooled to the temperature of 200° below zero Centigrade, it quickly fills with liquid air, and every gaseous substance, elemental or compound, at present known, amounting to anything like one per cent., and boiling at a temperature above—200°, must become liquid or solid under such

conditions. Thus when air is liquefied it does not appear as a clear transparent substance, but as a fluid containing more or less of a white deposit, due to the solidification of carbonic acid and other gaseous impurities, which floats in the transparent liquid oxygen and nitrogen. When air under high compression is used to produce the liquid in quantity, then, however carefully it may be purified before compression, it always takes up traces of foreign substances in its passage through the compressors, so that the amount of white solid associated with the liquid air may vary considerably, but is always present in greater or less quantity.

When I have been asked, during the last year or two, what is the nature of the solid, in so far as it does not consist of known atmospheric impurities, my answer has always been that I could not say, not having made a special study of the substance. Can this substance, which has been so often seen in the theatre of the Royal Institution, be in the main anything else than Rayleigh's new nitrogen in the solid form? If a hitherto unrecognized substance, elemental or compound, exists in air, having a density [compared to hydrogen] of about 19, and present to the extent of even a minute fraction of one per cent., chemists would infer that the material must be less volatile than nitrogen or oxygen, and, therefore, must be condensed with them in the process of liquefaction. Further, as the nitrogen of liquid air boils off first, leaving the oxygen with its higher boiling-point behind, so the new substance ought to remain liquid or solid after both these substances have distilled off. If the white solid (known impurities of course excepted) be not the new gas of Rayleigh, then the gas must liquefy along with the nitrogen and oxygen, and be approximately equal in volatility with one or the other. Then, on the other hand, the white substance certainly does not amount to one per cent. of the liquid, and whenever I have casually examined it, the substance has turned out to be a mixture of nitrous oxide, carbonic acid, and some other impurity. Therefore the amount of any unknown substance must necessarily be extremely small. One is forced to the conclusion that if the new nitrogen is present to the extent of one-

half to one per cent., and has a density of about 19, then it is, indeed, a strange substance, being as volatile as nitrogen or oxygen, and, therefore, not capable of separation by difference of boiling-point.

These facts in no way detract from the interest of Lord Rayleigh's discovery; they only add some additional interest to the subject, and may suggest some queries to be answered by further investigation.

In the above observations I have pointed out certain difficulties which suggest themselves as to the elementary character of the new constituent of the atmosphere, and its presence in normal air to anything like the amount of one per cent. If, however, we assume the substance separated by Lord Rayleigh and Professor Ramsay to be composed of known elements, then the experimental results can be easily explained. We have only to assume that when nitrogen enters into chemical combination with another substance, whether oxygen, as in the case of Lord Rayleigh's plan of working, or magnesium, as in that of Professor Ramsay, a small portion of the gas is condensed molecularly into an allotropic form, having one and a-half times its normal density. We are familiar with such action in the case of the transition of oxygen into ozone, and practically identical methods are being employed in the assumed separation of the new substance from air. It would appear that electrical discharges acting alone upon nitrogen do not condense it, and in this respect it differs from oxygen. Yet it is well known that electrical stimulation of nitrogen does produce two distinct spectra, presumably due to different molecular conditions.

The theoretical density of the new nitrogen compared to hydrogen should be 21, while the experimental numbers are between 19 and 20, though these are admittedly too low. Such a body, chemists would infer, ought to be characterized by great inertness, because phosphorus, the element most nearly allied to nitrogen, easily passes into an allotropic form known as red phosphorus, which is relatively to the yellow phosphorus an inert body. If, therefore, such an active substance as phosphorus becomes, in its condensed form, far less

active chemically, then by analogy nitrogen, so inert to start with, must, in its new form, become exceedingly inactive. No doubt the passage of the ordinary nitrogen, or the diatomic form of the substance, to the triatomic form of the same, takes place with evolution of heat, just as in the similar transition in the case of phosphorus. While this hypothesis accords with the facts, it does not, necessarily, support the view that the triatomic nitrogen is present to the extent of one-half per cent. in normal air. On the contrary, the inference is that the new substance is being manufactured by the respective experimenters, and not separated, as they imagine, from the ordinary air. If the suggested view is correct, it is certain that the allotropic nitrogen would be far less volatile than the ordinary variety, just as the vapor-pressure of red phosphorus is small as compared with that of the yellow, and, therefore, it ought to be separated from liquid air by its higher boiling point, even if it did not become solid at the existing temperature. Its non-appearance supports the view that it can be present in air, if present at all, only in exceedingly small amount. Yet were it produced in ever such small quantity—for example, by the passage of electric discharges—its very inertness would favor its accumulation, just as the high chemical activity of ozone tends to its dissipation. If, therefore, in the long course of ages, the quantity of this triatomic form of nitrogen remains inappreciable, we are scarcely entitled to assume its existence as a normal constituent of the atmosphere, unless we also assume that it is being utilized in some unknown way.

It is not the first time that chemists and physicists have been tempted to believe in the production of an allotropic form of nitrogen, and to accept it as explaining certain curious phenomena, but hitherto the assumption has always broken down on more careful investigation. This time we may be permitted to hope that the elusive allotropic form has been fairly captured.

CURRENT SCIENTIFIC DISCUSSION

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LORD SALISBURY ON EVOLUTION.

Of the many brilliant meetings of the British Association for the Advancement of Science none, perhaps, stands out more memorably than the one of 1860, held at Oxford, one year after the publication of Mr. Darwin's "Origin of Species," when the first great battle in defense of the new scientific creed was publicly fought. Compared with the bitter battles that were subsequently waged, it was, indeed, a weak contest, but it broke the path for that triumphant army which the hosts of science were slowly but surely gathering. From that day to this the facts of evolution have been steadily accumulating, and he would, indeed, be a blind naturalist, who to-day ventured the assertion that more facts were needed before the broad principles of transformism could be accepted. The case was proved years ago, and the world gradually settled down to the conviction that, even under the new philosophy, which threatened disruption in religion, politics, and the State, the wheels of commerce could still move and the principles of ethics be maintained on as high a basis as in the days of that more "lucid" philosophy when the denial of one's own existence was privileged.

After an interval of thirty-four years, the British Association has again met at Oxford, and to the Marquis of Salisbury, Chancellor of Oxford University, the President for this year, has fallen the task of reviewing the advances which science has made during recent years. The inaugural address, a piece of beautiful composition and diction, more brilliant than masterful in its presentation of facts, deals more with the negative side of science than the positive, and emphasizes the obscurity which still surrounds the three greatest of "scientific enigmas:" the enigmas of elementary atoms, ether and life. As part of the last-named subject the noble Marquis

reviews the present status of evolution, and after paying respectful homage to the great naturalist through whom the doctrine of evolution was given birth, ventures to assail the theory of natural selection, and once more to implant upon the world its exceedingly willing and pliable predecessor, the principle of design. Lord Salisbury's principal point of attack falls upon the lack of agreement that exists, or is supposed to exist, between the mathematicians and biologists as regards the time-limit in our planet; the geologist and biologist, it is claimed, require "many hundred million years" to have effected that "chain of [organic] change so vast, of which the smallest link is longer than our recorded history," while Lord Kelvin will grant only a paltry hundred million years as the length of time during which our (cooling) globe could have supported either animal or vegetable life.

The aspect of attacking or defending the theory of natural selection on a plus or minus sign beyond a hundred million years, will probably strike most people as bordering on the ludicrous; but to assume that fine knowledge which makes it all but certain that several hundred millions of years were, in fact, required to evolve that organic chain which we now see before us, is still more ludicrous. It is, indeed, almost inconceivable that any earnest student could seriously consider a calculation in which the known elements are so fragmentary as they are in the present case. It is true that Lord Salisbury asserts that in a historic period of some three thousand years "progressive variation has not advanced by a single step perceptible to our eyes," but we venture to believe that the noble lord would find it much more difficult to prove his assertion than would his opponents the reverse. It is the old-time argument once more brought to the front, only in the present instance no attempt is made to satisfy statements by facts.

Lord Salisbury's own position regarding natural selection is clearly stated in his words: "We cannot even, with more or less ease, imagine it." This is, surely, a remarkable admission to make, and it comes with startling force from a President of, perhaps, the most distinguished and powerful

scientific body in the world. With becoming modesty, however, the President declared himself to be only a layman in science, and it would be uncharitable to heap the sins of wrong scientific perception upon a mind which virtually disclaims all true knowledge of science. Lord Salisbury justly attacks Weismann for accepting natural selection "because it is the only possible explanation that we can conceive," "because all other apparent principles of explanation fail us." He classes this argument with that of the politician. "In politics there is occasionally a certain validity in the argument, for it sometimes happens that some definite course must be taken, even though no course is free from objection. But such a line of reasoning is utterly out of place in science. We are under no obligation to find a theory, if the facts will not provide one." All true lovers of science will agree with these sentiments, and their emphasis cannot be made too strong to the scientific community. Unfortunately, personal fancies too often interfere with a proper conception of one's own mental attitude, and often only when they are pointed out by others are the shortcomings of our mind made known to us. Salisbury justly objects to the Weismannian method, but he himself admits the same tendencies when he asserts that "if natural selection is rejected, we have no resource but to fall back on the mediate, or immediate, agency of a principle of design." To the scientist it will appear strange that the principle of design should have certain rights, while that of natural selection has none.

THE ORIGIN OF OCEANIC CURRENTS.

The doubt and obscurity which for so long shrouded the history of oceanic currents seem to have been forever dispelled. However tempting other explanations may appear, scientists have gradually settled down to the conviction, made inevitable by a practical demonstration, that the guiding power of these currents is resident in the non-periodic winds, or such as blow constantly from definite quarters. An exceedingly ingenious device to show this has been prepared by Mr. Clayden, and is in the form of a model, con-

taining a water area shaped like the Atlantic, over whose surface lycopodium dust has been sprinkled to show the water movement that is generated by air-currents blowing from specially directed nozzles. These nozzles are so placed as to represent the direction of permanent winds. Not only were, by this means, the main currents of the Atlantic reproduced in miniature and with great accuracy, but also the minor drifts, and even a number of the interacting return currents, such as the eastwardly-trending winter equatorial current. Referring to this demonstration, in a recent address, Captain Wharton, F. R. S., Chief Hydrographer to the British Navy, stated that it dispelled the last doubt that he held on the subject. "After long hesitation and much argument, I think it may be now safely held that the prime motor of the surface currents is the wind. Not, by any means, the wind that may blow, and even persistently blow, over the portion of the water that is moving, more or less rapidly, in any direction, but the great winds which blow generally from the same general quarter over vast areas. These, combined with deflection from the land, settle the main surface circulation. . . . . The trade winds are the prime motors. They cause a surface movement of no great velocity over large areas, in the same general direction as that in which they blow. These drifts, after meeting and combining their forces, eventually impinge on the land. They are diverted and concentrated, and increase in speed. They either pour through passages between islands, as into the Caribbean Sea, are pressed up by the land, and escape by the only outlet possible—as, for example, the Strait of Florida, and form a great ocean current like the Gulf Stream—or, as in the case of the Agulhas current, and the powerful stream which runs north along the Zanzibar coast, they are simply pressed up against and diverted by the land, and run along it with increased rapidity. These rapid currents are eventually apparently lost in the oceans, but they in their turn originate movements of a slower character, which, on again passing over shallow water, or on meeting land, develop once more well-defined currents. . . . . Compared to the great circulation

from this source, the effect of differences of temperature, or of specific gravity, is insignificant, though no doubt they play their part, especially in causing slow under-circulation, and in a greater degree the vertical mixing of the lower waters."

THE INTERNAL HEAT OF THE EARTH IN ITS EFFECT UPON OUR CLIMATE.

It is a common belief, and one that is shared by many scientists, that the climate of our planet has been largely influenced by the thermal conditions of its interior. The more elevated temperatures of past periods have been associated with the earlier warm condition of the earth; the temperate climate of to-day, with the comparative cold which has resulted from a progressive cooling off and radiation of heat into space. Lord Kelvin (Sir William Thomson), who has few peers in his domain of mathematical physics, has in his recently published "Geology and General Physics," given some plain utterances on this subject, which will be a rude shock to many who have definitely composed their minds to old notions. Referring to the warmer climate, which is evidenced as having existed at one time all over the earth, he says: "The earth might be a globe of white hot iron, covered with a crust of rock two thousand feet thick, or there might be an ice-cold temperature within fifty feet of the surface, yet the climate could not on that account be sensibly different from what it is, or the soil be sensibly more or less genial than it is for the roots of trees or smaller plants." Manifestly, therefore, the duration of life upon the surface can in no way be dependent upon the length or intensity of heat-supply from the interior. This, it is claimed, could not at the present time melt a millimetre thickness of ice per annum.

Lord Kelvin explains the past warm climates on what he terms the "almost infinitely probable" hypothesis of *a warmer sun*. He takes occasion, in this connection, to point out the fallacy which lurks in the general belief, repeated in many geological text-books, that the increase of temperature from the surface of the earth to the interior is an arithmetically progressive one; it is said to be asymptotic, and it is implied

that the temperature at or near the center *need* not be higher than two or three thousand degrees.

THE PROSPECTS OF ARCTIC EXPLORATION.

At no time, probably, in the history of Arctic exploration, have the possibilities of successful achievement in the icy north been put to a severer test than they have been this year. Four, more or less well-equipped, expeditions, each one framed with the ultimate hope of reaching the "farthest north," were in the field at one time, and with each, seemingly, lay an equal chance of attaining the end in view. Wise speculation has decided in favor of this or that route, and against certain probabilities here or there, but he would, indeed, be a prophet who, in the present uncertainties of exploration, could foretell the issue in the friendly race for discovery, or indicate within a near probability the actual conquest that would be achieved. The steady advances that have been made in Arctic work, combined with an almost endless resource that has been obtained from the experiences of travelers in other regions; the new methods by which old appliances are treated, and above all, the more conscientious study of the conditions that are likely to confront the explorer, all gave hope for the result—a hope that was strengthened by the knowledge that the commanders of the several expeditions were commanders in fact, untrammeled by government orders, and free to act as their best judgment dictated.

The unfortunate ending of two of the expeditions shows that these hopes were not to be realized, and again demonstrates the uncertainties that attach to Arctic explorations generally. Mr. Peary's brilliant record of 1892 had raised high expectations for this summer's venture, and it was confidently believed that, unless some unlooked-for disaster early overwhelmed his party, a new mile-stone would be planted in the path of Arctic discovery. On March 6 he and his seven associates, with ninety dogs and thirteen sledges, began their arduous journey across the inland ice of Greenland, following much the same course that was taken by him two years before. Almost from the start the expedition encoun-

tered the worst of Arctic weather—heavy snows, furious winds, and an exceedingly low temperature (—50° to —60° F.)—and before long its effects told distressingly upon nearly all the members of the party. The dogs are reported to have frozen into "solid blocks," and of the ninety which were to have proved the dependence of the party for a period of five months, sixty-five succumbed within a month and a half, the length of time during which the expedition, or a part of it, obstinately battled against the elements which were daily threatening its destruction. Less than one hundred and fifty miles were covered on the inland ice up to April 13, when, seeing that progress was more in the name than in the fact, and that his frost-bitten and otherwise incapacitated party—one-half of whom had already been obliged to return—would be unable to accomplish their mission, the gallant commander accepted defeat, and turned his back to the quarter upon which he had centred all his hopes. On April 20 he arrived at Anniversary Lodge, his winter quarters, on Bowdoin Bay. With a heroic determination to attain his object, Mr. Peary once more proposes to attack the problem, and toward this end he and two of his associates, Matthew Henson and Hugh J. Lee, have remained over in the icy "land of desolation."

Disaster, the crushing by ice of the *Ragnvald Jarl*, the relief vessel of the expedition, has overtaken the Wellman party, and we have another added to the list of ordinary Arctic casualties. The accident happened at Walden Island, in lat. 80° 37′ N., four days after Mr. Wellman and his thirteen associates landed (May 24) on the ice, to begin their struggle with the great northern "pack." With an energy and determination worthy of the highest admiration, the commander of the expedition, after returning to the scene of the disaster and there reconstructing his crushed vessel into a temporary storehouse or shelter, once more started on his perilous journey northward. The party, as late as June 17, were reported in good condition and still pressing forward, but the unfavorable condition of the ice made advance exceedingly laborious, and at a later day, when a relief vessel arrived from Norway, the expedition was abandoned.

THE AGE OF THE NIAGARA FALLS AND THE MEASURE OF GEOLOGICAL TIME.

Of the many "facts" which have from time to time been brought forward to prove the comparatively recent occurrence of the Glacial Period, few have been so generally appealed to as those which are bound up with the work of post-glacial rivers. Knowing the rate of their work, or the rate with which they have excavated their channels, it is seemingly an easy matter to ascertain the length of time during which they have been in existence; and where such streams can be shown to have directly followed the melting of the ice, it follows that they are the measure of the time which has elapsed since the melting of the ice (or since the close of the Glacial Period). The Niagara River (or gorge) has long been assumed by many geologists to be the test-gauge of measurement in the case of the American Ice Age, and officially or semi-officially its antiquity has been rated at but little more than seven thousand years. In this length of time, in other words, as determined by a careful computation of the recession of the falls, and an assumption of past work based upon its modern potentiality, it had cut out the few miles of cañon which terminate at Queenstown and shaped its existing destinies. Born with, or shortly after, the melting of the ice, it was the determinant of time of the Ice Period, and to the geologists who favored a barely more than recent existence of the ice, the evidence that it carried with it was of the most convincing kind. In reality, however, it cannot be said that there ever was any evidence, that could be called such, that indicated how soon after the melting of the ice the river was first called into existence; it may have been shortly after, or it may have been long after; the facts of geology give little evidence on this point, and nothing that is worth while building upon. Conservative geologists carefully guarded themselves in this connection, and declined to use the age-formula which was so eagerly presented to them by the too zealous advocates of limitation in time. It would now appear, moreover, from the recent careful analysis of Prof. J. W. Spencer, that the very age of the river is under-

stated by nearly five times, his determinations of work giving to it a period of not less than thirty-two thousand years, instead of the seven thousand that had been very generally assumed. The backward wear is thus much less rapid than has been commonly supposed, and a few additional thousand years are added to the lease of life of this most wonderful of nature's exhibits.

No problem in geology is, perhaps, more thoroughly sealed than that of time-periods—the measurement of work accomplished by means of the yearly calendar. Whether it be the measurement of the age of our planet, the rate at which sediments are formed or unformed, or the velocity of organic evolution, so many uncertain factors are involved in the calculation that at best only a possibility of correctness in any obtained result can be assumed. Mathematicians are apt to force the issue of their calculations upon the geologist, but the geology of the calculation must be first established before the figures that are planted upon it can be given much weight.

THE MINIMUM TEMPERATURE OF VISIBILITY.

Mr. P. L. Gray, of the Mason Science College, of Birmingham, England, has recently made some interesting experiments to determine the lowest temperatures at which bodies heated could be made visible in the dark. The experiments were conducted with bright and lamp-blacked platinum strips, and give the following results: During the morning hours, when the eye is least sensitive to radiation of low frequency, the minimum temperature of visibility of a solid is about 470° C.; at night-time this temperature is reduced to 410° C.; and after resting the eye for some time in complete darkness, the temperature may be still further reduced to 370°. Different people's eyes differ in their "luminous" perceptive powers, but seemingly to no great extent. The losing color, or color of last appearance, however, seems to be variously interpreted, to some appearing red or whitish, and to others, lilac and yellow.